Chapter 16
State of India's Bats Research and Conservation Action Priorities

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Introduction

In 2002, the Status of South Asian Chiroptera: Conservation Assessment and Management Plan (CAMP) workshop was organised by Zoo Outreach Organisation (ZOO), the International Union for the Conservation of Nature (IUCN) Species Survival Commission (SSC) Conservation Breeding Specialist Group, and the former Chiroptera Conservation and Information Network of South Asia and hosted by Madurai Kamaraj University[43]. This landmark workshop set the precedent for a roadmap for bat research and conservation in India and South Asia in the coming years. During this workshop, 43 bat experts from Nepal, Sri Lanka, India, Myanmar, the United Kingdom, and the United States assessed the status of all 120 bat species known from South Asia at that time. Based on their status assessments for these species and their field experiences, the participants made recommendations for further research and conservation in the region.

The 2002 CAMP report recommendations put a strong emphasis on research priorities, including the importance of conducting surveys to ascertain the status of different bat species at a time when very little was known about the distribution of Indian bats[43]. The report emphasised the need for surveying previously unsurveyed regions and in re-surveying areas where bat species seemed to have disappeared (e.g., *Hipposideros durgadasi* in Jabalpur, Madhya Pradesh). To supplement field research, the report drew attention to the needs for building capacity in bat research and for the development of bat identification keys. Additionally, ecological research was highlighted as a high priority to document the ecological value of bats and to understand the impacts of potential threats to bat populations[43].

Among the CAMP report's conservation recommendations, the critical need for wide-reaching public awareness campaigns and the removal of fruit bats from the vermin list in Schedule V of the Wild Life (Protection) Act, 1972 stood out[43]. The report also emphasised the need to protect roosting sites and other important habitats of threatened bat species through government policies. The Archaeological Survey of India (ASI) was identified as a key stakeholder in this regard. The report also explicitly highlighted the needs to include

Report contributors voting for the top 10 research and conservation priorities at SoIBats Workshop in Bengaluru. Photo: Tikily Tayeng

bat researchers in Environmental Impact Assessments (EIAs) and to identify migratory bats so that they can be protected through international agreements such as the Convention on Migratory Species (CMS)[43]. These two recommendations were remarkable considering that EIAs were heavily biased towards charismatic animals and tropical bats were seldom considered migratory species at that time.

Twenty-two years later, several of these recommendations were picked up by the CAMP workshop participants, their students, their mentees, or the next generation of bat researchers. For example, workshops on bat taxonomy and ecology have been organised in Bengaluru (2010), Goa (2015), Hyderabad (2016 & 2020), and Thrissur (2023, 2024, 2025). Chelmala Srinivasulu and colleagues' key to South Asian bats[44] has served as a gold standard for field identification in all bat surveys and ecological research in India over the past 15 years. Threatened species, such as *Hipposideros hypophyllus* and *H. durgadasi*, that faced the risk of being lost to oblivion were rediscovered and are now actively being protected[45][46]. Marking a meaningful shift in government wildlife policy, fruit bats were removed from the vermin list in 2022, and six bat species were accorded the highest protection (Schedule I) per the Indian Wild Life (Protection) Act, 1972[47] (Chapter 11).

The significant strides that the Indian bat research community has taken as a whole over the last few decades are worthy of praise. However, some key research and conservation priorities identified in the 2002 CAMP report have either not been addressed or still have large knowledge gaps. These include the continued lack of natural history or ecological knowledge for most bat species (see Section II) along with limited systematic monitoring of rare and threatened species (Chapter 4). Our meagre understanding of the ecosystem services provided by Indian bats (Chapter 10) still slows down our efforts to improve the public image of these invaluable species.

New challenges and opportunities have also emerged over the past two decades. Anthropogenic climate change and the growth of renewable energy ventures have all escalated as substantial threats to bat populations throughout India. Countering these obstacles are advances in technology to support bat research and outreach. Acoustic monitoring, which was practically unheard of in 2002, has become indispensable in bat research. Meanwhile, social media have burgeoned into important means through which to disseminate bat-related information and educational messages to promote human–bat coexistence (Chapter 14). Most encouragingly, there is a growing culture of collaboration and broad recognition of the importance of multi-stakeholder inclusion within the field of Indian chiropterology (Chapter 12).

Set in the context of these past problems, contemporary challenges, and propitious opportunities, prioritised research and conservation action recommendations were developed by participants in the State of India's Bats (2024–2025) workshop (SoIBats). Below, we not only introduce these research and conservation actions but also describe the process by which they were ranked and the means through which their impact can be amplified to support India's bats over the next twenty years.

"How-Now-Wow": Prioritisation Methods for Recommendations

During the SoIBats in-person workshop in Bengaluru in June 2024, each of four thematic working groups (Ecology and Biology; Ecosystem Services; Policy and Public Engagement; and Taxonomy, Systematics, and Monitoring) generated a list of ten research and ten conservation action priorities for the benefit of Indian bats (detailed in "State of India's Bats (2024–2025) Methods"). Consequently, a total of 40 recommendations for conservation and 40 recommendations for research were produced by all four working groups (Appendix 4). The workshop facilitation team then formed two master lists, one for research suggestions and one for conservation actions, by eliminating duplicates or merging any overlapping recommendations between the working group lists. Participants were presented with these two master lists and asked to evaluate each individual recommendation using the "How-Now-Wow" classification scheme (Box 16.1). Workshop attendees were instructed to classify each recommendation into one of the three categories (i.e., How, Now, Wow) based on a timeline within the next 10 years. Each participant was restricted to one categorising vote per recommendation and could choose to abstain from evaluating recommendations. Assessments were not anonymous, and all attendees could see each other's votes throughout the prioritisation exercise.

Following the "How-Now-Wow" assessment exercise, the workshop facilitation team compiled the categorisa-

tions for each research and conservation recommendation. The SoIBats core planning team ("State of India's Bats (2024–2025) Methods") reached the consensus that recommendations that were highly innovative and/or more likely to be implemented should be ranked higher than those that were unfeasible and/or unlikely to be implemented. Therefore, the combined scores for each recommendation's "Wow" and "Now" votes were used for the initial rankings of conservation actions and of research recommendations (i.e., those with the highest scores were considered of the greatest priority). In the case of tied rankings (i.e., when more than one recommendation within the conservation action list or within the research list received the same combined score), the recommendation with the lowest number of "How" votes was judged to be of greater priority than the other recommendation(s) sharing the same initial ranking.

Based on this ranking system, ten recommendations of the greatest priority were identified for Indian bat research (Table 16.1) and for Indian bat conservation (Table 16.2). These priorities are further detailed below, and the applicability of the conservation action priorities to ameliorate the various threats impacting Indian bats is explored in Appendix 5.

Box 16.1 The "How-Now-Wow" classification scheme uses a 2x2 matrix with originality on the X-axis and feasibility on the Y-axis. "How" ideas (○ yellow in the grid) are original and innovative ideas but the resources or the tools to pursue them may not currently be available. "Now" ideas (● blue in the grid) are low-hanging fruits: ideas that may not be innovative but are low risk and easy to implement. "Wow" ideas (○ green in the grid) are innovative, breakthrough ideas that are feasible and have the potential to make a huge impact.

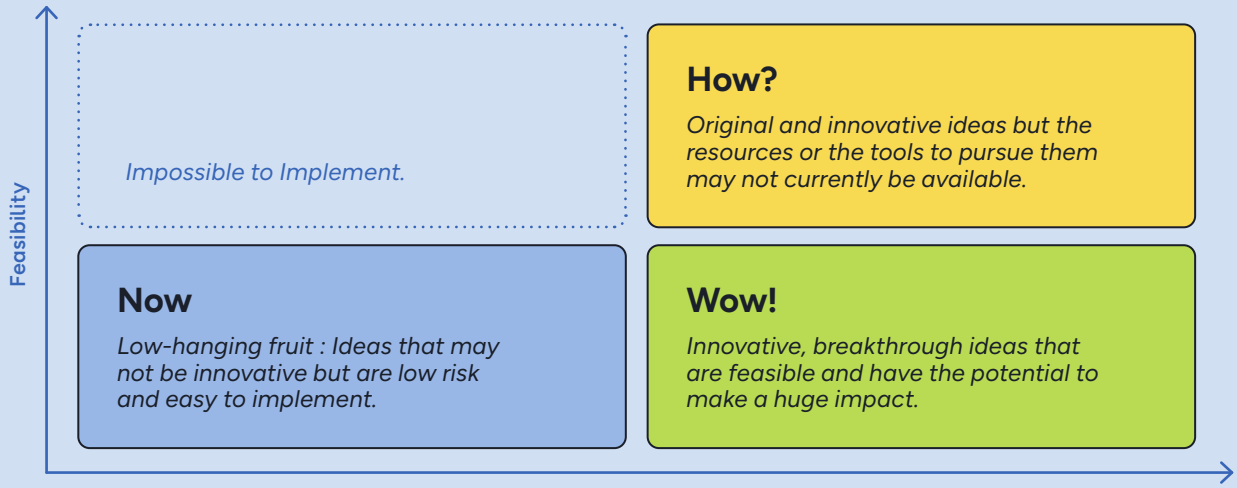

Table 16.1 The top ten priorities for future bat research in India. Participant categorisations of each recommendation according to the "How-Now-Wow" system (Box 16.1) are also provided. Priorities with more "Wow" votes are highlighted in green, and those with more "Now" votes are highlighted in blue. None of these priorities received any "How" votes.

Top 10 Research Priorities	"Wow" votes	"Now" votes
Identifying "bat hotspots"	11	4
Building comprehensive call libraries	12	2
Long-term monitoring to understand the effects of climate change on bats	3	10
Identifying home ranges and critical habitat of threatened bat species	6	5
Conducting detailed studies on bat diets (for priority species)	10	1
Investigating the pathogen diversity in Indian bats and potential disease interfaces	5	6
Enhancing taxonomic knowledge of data deficient species	9	2
Characterising the impact of urbanisation and light pollution on bats	3	8
Identifying "high priority" bat species	10	0
Establishing molecular resources for studying bat ecology	4	5

Table 16.2 The top ten priorities for future bat conservation in India. Participant categorisations of each recommendation according to the "How-Now-Wow" system (Box 16.1) are also provided. Priorities with more "Wow" votes are highlighted in green, and those with more "Now" votes are highlighted in blue. None of these priorities received any "How" votes.

Top 10 Conservation Action Priorities	"Wow" votes	"Now" votes
Building a network of stakeholders for engagement in conservation	10	6
Increasing public awareness through targeted outreach activities and via social media	12	4
Conserving bat habitats through protected areas	4	11
Conducting Red List assessments for India's endemic bats	4	10
Developing best practices guidance for bat research, human–bat interactions, and bat rescue, rehabilitation, and release	7	4
Incorporating bats as integral parts of national and state biodiversity strategy action plans	9	2
Protecting historical bat roosts	6	5
Identifying key bat diversity areas	8	2
Drafting management action plans for "bat hotspots"	8	2
Including bats and bat experts in EIAs	5	4

SoIBats Research and Conservation Action Priorities

Top ten research priorities for Indian bats

1. Identifying "bat hotspots". "Bat hotspot" here (and below) may be loosely defined as an area that contains:

- High species diversity,
- Important habitats for endemic species,
- Populations of globally threatened species or species of national importance, and/or
- Large roosting or nursing colonies that may be under immediate threat.

Identifying bat hotspots will require targeted surveys combining trapping and acoustic sampling. Certain areas may be prioritised based on prior biodiversity and biogeographic knowledge. The support of state forest departments and funding sources is crucial for facilitating biodiversity documentation.

2. Building comprehensive call libraries. Bat acoustic detectors have become an indispensable tool in surveying and monitoring bat communities. However, interpretation of the recordings to the species level is often limited by the lack of comprehensive reference libraries for echolocation calls. At present, bat echolocation calls have been documented for only about three-quarters of Indian bat species[19][21][48][49][50]. Whenever possible, field researchers should include the collection of acoustic data to augment our reference material for the echolocation calls of different bat species and/or regional species pools. Increasing the number of sample recordings for species in different habitats and geographical locations will also help to develop robust call classifiers for different bat species and biogeographic regions within India.

3. Long-term monitoring to understand the effects of climate change on bats. To date, studies on the impacts of climate change on bats are biased towards the Global North, where long-term data on bat distribution, population trends, and demographics are more available. Even in these cases, research has been primarily focused on predictive modelling of species distributions under varying climate scenarios rather than on empirical investigations of bats' genetic, physiological, or behavioural responses to climate change effects[51]. To fill these knowledge gaps, we recommend initiating long-term monitoring of bats, targeting areas where bat research has already been, or is being, conducted to assess shifts in range, habitat use, or other behavioural or physiological factors in adaptation to climate changes. In the longer term, we encourage researchers to collaboratively scale up these types of case studies to other biogeographic regions, ideally with the support of sustainable funding.

4. Identifying home ranges and critical habitat of threatened bat species. Seven bat species endemic to India are considered threatened under the IUCN Red List (*Hipposideros durgadasi, H. hypophyllus, H. nicobarulae, H. pomona, Latidens salimalii, Pteropus faunulus*, and *Rhinolophus cognatus*)[12]-[18], and six bat species (*Hipposideros hypophyllus, Latidens salimalii, Otomops wroughtoni, Pteropus faunulus, P. melanotus*, and *Rhinolophus cognatus*) are recognised as threatened by the Government of India in their listing as Schedule I protected species under the Indian Wild Life (Protection) Act, 1972[47]. Historically, the conservation of threatened bat species has often been restricted to measures protecting their roosting habitat. Expanding conservation efforts to include protection of threatened species' foraging, breeding, and other critical habitats is hindered by the absence of data on their home ranges, habitat use, and habitat preferences. Therefore, we recommend that researchers focus on home range and habitat ecology studies of threatened species through means such as radio telemetry, Global Positioning System (GPS) transmitters, or acoustic sampling (as applicable based on the species of interest) (Chapter 6, Chapter 7).

5. Conducting detailed studies on bat diets (for priority species). In addition to identifying home ranges and crucial habitats for threatened species, we also recommend studying their diet, preferably through DNA metabarcoding (Chapter 5). Identification of important dietary items across seasons will enable more holistic habitat conservation and restoration efforts that take into account threatened bats' requirements and those of the species on which they feed. We also recommend that researchers conduct dietary studies on priority species (not necessarily threatened species) that have the potential to offer significant benefits to humans through their dietary habits. For example, bat species that are common and widespread in distribution, abundant in certain regions, involved in human–bat interactions, and/or frequently use human-dominated habitats may provide disproportionately salient ecosystem services to various stakeholder groups (Chapter 10). In studying the diets of these priority species, we can better quantify the contributions of bats to human and ecosystem well-being, which will provide additional fodder for bat awareness and conservation outreach campaigns.

6. Investigating the pathogen diversity in Indian bats and potential disease interfaces. In the wake of consecutive Nipah virus outbreaks in India (specifically in Kerala) and the COVID-19 pandemic, we recommend that virologists, epidemiologists, and bat researchers collaborate to investigate the disease ecology of bats within a One Health framework. Epidemiological investigations into the potential causes of disease outbreaks can be hampered by a lack of understanding of bats and their disease ecology. Working collaboratively across disciplines can help mitigate this impediment and facilitate the design of more effective, disease-specific prevention measures to reduce future outbreaks for human and bat health (Chapter 8).

Fly eggs on a bat. Investigating bat ectoparasites (such as these flies), endoparasites, and pathogens is among the top research priorities identified by the State of India's Bats team. Photo: Nithin Divakar

7. Enhancing taxonomic knowledge of data deficient species. Despite the great importance of taxonomic and systematics research to understanding and, thus, conserving India's diversity of bat species, there continues to be a paucity of these types of data for many regions and bat taxa in the country (Chapter 2). We recommend that researchers adopt a transdisciplinary approach and employ the most advanced technology to address gaps in our taxonomic knowledge of India's bats. For instance, areas with data deficient species should be resurveyed, more specimens should be collected and analysed to resolve indeterminate taxonomy, and taxonomists and systematists should collaborate with museums at home and abroad to critically evaluate type specimens of questionable taxonomic assignment (Section I).

8. Characterising the impact of urbanisation and light pollution on bats. Currently, 36% of India's population lives in cities[52]. The country's urban population is steadily rising, and unsustainable urban development is projected to expand[53]. Acknowledging this growth of urban areas and their associated infrastructure combined with our limited understanding of the impacts of urbanisation and light pollution on bats (Chapter 15), we recommend that researchers expand on the work of Murugavel et al. (2021, 2023)[3][40] to empirically evaluate the effects of these threats on bat individuals, populations, and species across India.

9. Identifying "high-priority" bat species. The mention of "high-priority" bat species automatically makes one imagine threatened species. However, as discussed above in Research Priority 5, "high-priority" bat species can refer to non-threatened taxa as well. In addition to bat species that offer valued ecosystem services, several non-threatened bat species may be vulnerable to emerging threats such that they might soon become threatened. This recommendation, not entirely independent of the ones above, acknowledges this knowledge gap and urges researchers to quantify threats and their population-level impacts. This recommendation may also be seen as a precedent towards identifying model bat species for studying the impacts of different threats.

10. Establishing molecular resources for studying bat ecology. This research recommendation leverages the increasing capacity and expertise for conducting molecular research in the country. We recommend that researchers focus on collecting baseline molecular data applicable in population ecological, demographic, and conservation genetic research. Some examples of the benefits of this type of data compilation are:

- Quantifying genetic diversity (or lack thereof) within and between populations to critically evaluate the effects of various threats and/or management actions on bats.
- Sequencing genomes of different bat species for application in understanding gene flow and identifying species adaptations.
- DNA barcoding of vouchered and carefully identified bat specimens so that future studies can rely on genetic identification of individuals sampled in the field.
- Collaborating with entomologists and DNA barcoding insect prey species to enable the identification of prey remains through DNA metabarcoding.

Top ten conservation action priorities for Indian bats

1. Building a network of stakeholders for engagement in conservation. Bat conservation is inherently interdisciplinary in nature. As comprehensively examined in Chapter 12, a wide diversity of stakeholders from the public, private, and non-profit sectors are interested in, affected by, or significantly influence bat management and conservation in India. Inclusive engagement with these stakeholders can benefit bat conservation at the community, regional, and national levels by improving the quality and effectiveness of conservation interventions and ensuring the buy-in of key stakeholders to support their successful implementation. We strongly encourage bat researchers and practitioners to create a formal network of collaborators to plan, implement, assess, and adapt bat conservation strategies across all relevant contexts and scales throughout India.

2. Increasing public awareness through targeted outreach activities and via social media. The majority of India's bat species are primarily threatened by human-driven factors (Chapter 15). The solutions to these threats equally lie with humans, such as through the development, support, and implementation of policies and conservation interventions to protect bats and their habitats. To promote human–bat coexistence and generate public support for bat conservation measures, we recommend that educational outreach and behaviour-change initiatives be used to target key stakeholders and communities across India (Chapter 14). Direct engagement with

communities through bat walks and school programs can be organised to increase positive attitudes towards bats. Concurrently, educational outreach to wildlife law enforcement personnel, natural resource managers, policymakers, and other agents responsible for overseeing bats and their habitats can improve the planning and implementation of bat protective measures (Chapter 11). We further recommend that bat conservationists rely on conservation marketing and psychological principles to design persuasive, bat-positive messaging that can be shared widely via traditional and social media outlets.

3. Conserving bat habitats through protected areas. Although approximately 187,163 km^2 of India is managed as legally protected national parks, wildlife sanctuaries, community reserves, or conservation reserves, this protected area only represents a small percentage of the estimated 827,356.95 km^2 of forested lands and a fraction of the cave habitats that support the country's diversity of bats[54]. We advocate for identifying and prioritising "bat hotspots" (Research Priority 1) and critical habitats for threatened species that are currently outside the boundaries of India's protected area system. Bat researchers should collaborate with government agencies, policymakers, local and Indigenous communities, and private landholders to safeguard these important landscapes either as legal protected areas, Indigenous and Community Conserved Areas, conservation trusts (e.g., for privately-owned land), and other binding mechanisms for habitat protection.

4. Conducting Red List assessments for India's endemic bats. We encourage India's bat experts to work with the IUCN Red List Authority for the IUCN SSC Bat Specialist Group to regularly coordinate IUCN Red List assessments for all 135 species of Indian bats. Furthermore, we suggest that bat species endemic to India that are currently threatened, at elevated risk for becoming threatened in the near future, and/or previously listed as "Data Deficient" be prioritised for reassessments (Chapter 15). Bat researchers should also consider regional, national, and state- or union territory-level Red List assessments to initiate bat conservation across geographical scales.

5. Developing best practices guidance for bat research, human–bat interactions, and bat rescue, rehabilitation, and release. We recognise the need for developing Standard Operating Procedures (SOP) and guidelines to ensure that human–bat interactions (e.g., use of bats in research and education; captive care of bats; general public's direct and indirect contact with wild bats) are as humane, safe (for both bats and humans), and ethical as possible. We encourage bat researchers to draft and accept bat-specific guidelines for minimising stress, safeguarding animal welfare, and protecting the health and safety of all parties during the capture, handling, care, euthanasia, and other activities involved in the use of bats for research and/or educational purposes (e.g., those provided by the American Society of Mammalogists[55]). Most bat researchers receive questions from the general public on how to deal with bat situations, such as how to evict bats from their private properties or how to manage flying foxes in spaces that are used by people. In view of this, we recommend that researchers work together to craft advice (e.g., in the form of Frequently Asked Questions) for problems that the general public frequently faces with bats. Additionally, wildlife rescuers and rehabilitators frequently seek suggestions on rehabilitating bats from field researchers. We recommend that bat researchers and conservationists collaborate with wildlife caregivers and veterinarians to draft evidence-based best practices for the rescue, rehabilitation, husbandry, release, and post-release monitoring of all species of Indian bats (sensu the captive and veterinary care reference for insectivorous bats published by Bat World[56]).

6. Incorporating bats as integral parts of national and state biodiversity strategy action plans. In a country where conservation is typically centred on charismatic, large mammals[57], we push for greater acknowledgement of the fact that bats are the most species-rich order of mammals. Given their vast diversity and cosmopolitan distribution across India, we recommend pushing for their inclusion in all relevant local to national level biodiversity conservation plans.

7. Protecting historical bat roosts. Bats and humans having been living together for millenia in India, so it comes as no surprise that bats have adapted to use human structures as roosting and breeding sites. However, as historical buildings are renovated or replaced with modern architecture and as religious, historic, and archaeological sites are managed to boost tourism, bats are losing critical habitats with adverse effects on bat populations and species throughout India (Chapter 15). The Archaeological Survey of India (ASI) manages sites for heritage conservation that are often inhabited by bats (Chapter 11, Chapter 12). Unfortunately, bats are usually seen as a nuisance in these properties. We recommend working closely with the ASI to frame plans for bat conservation under the umbrella of heritage conservation.

8. Identifying key bat diversity areas. Chiropterologists cannot efficaciously conserve bats or protect and restore crucial bat habitats without knowing where these bats and habitats are geographically (and temporally, in the case of migratory species) located. We recommend that bat researchers and conservationists prioritise the identification of "bat hotspots" as defined in Research Priority 1 to inform integrated and adaptive strategies to protect and expand key areas of high bat diversity.

9. Drafting management action plans for "bat hotspots". The scope of this report is limited to reviewing the current state of bat research and conservation in India and presenting opportunities for the future. As a next step, we recommend that researchers use this knowledge to liaise with key bat conservation stakeholders (Chapter 12) and prepare holistic management and conservation action plans for "bat hotspots" and "high priority" bat species (see Research Priorities 1 and 9). Initiation of these types of multi-stakeholder, multifaceted plans will realise the SoIBats report's full potential.

10. Including bats and bat experts in Environmental Impact Assessments. To date, negative impacts on bats remain largely unexplored in Environmental Impact Assessments (EIAs) mandated for developmental projects. This is often due to the lack of expertise in bats among those conducting these EIAs. We recommend including bat experts in EIAs wherever applicable. This recommendation is particularly relevant for wind energy projects and road-widening projects that are known to threaten bat populations globally (Chapter 15).

Leveraging Connections to Amplify Impact

Most of the research and conservation action priorities described above are interconnected or interdependent such that when combined, their impact is synergistic rather than simply additive (Figure 16.1). By collectively acting upon these priorities in tandem, researchers, conservationists, and other key stakeholders can maximise the holistic bat conservation achieved through their cumulative efforts.

For example, the enhancement of taxonomic knowledge (Research Priority 7), the compilation of echolocation reference libraries (Research Priority 2), and the development of genomic resources for population studies (Research Priority 10) are foundational for achieving broader research and conservation objectives. Developing comprehensive acoustic reference libraries plays a critical role in advancing the effectiveness of acoustic monitoring. Identification of acoustic recording to the species level enables us to know when and where species occur, which is vital to identifying important sites and habitats for protection (Research Priority 4). If a species is not threatened, acoustic monitoring may still aid in identifying population declines, thereby addressing the objective of identifying "high-priority species" for conservation (Research Priority 9). Acoustic sampling can also be used to understand the impacts of anthropogenic stressors such as urbanisation (Research Priority 8) and to identify disease interfaces through data on habitat use (Research Priority 6). When repeated over years, the results of acoustic monitoring can assist in understanding the impacts of climate change on bats (Research Priority 3). When combined, all the pieces of information gathered through acoustic monitoring can contribute data needed for Red List assessments of Indian bats (Conservation Priority 4).

Building echolocation reference libraries rests heavily on researchers' taxonomic knowledge (Research Priority 7). It is recommended that voucher recordings from an individual bat are substantiated with morphological and genetic identification. Additionally, taxonomic splits through the identification of cryptic species help delineate "bat hotspots" (Research Priority 1) as when an erstwhile wide-ranging species is suddenly found to occur in a narrow geographic range. However, identifying cryptic species greatly relies on the quality of molecular samples and databases (Research Priority 10). Moreover, genomic tools can be used to predict bats' responses to climate change (Research Priority 3).

The fruitful pursuit of these bat research priorities and the successful implementation of these bat conservation priorities rests soundly on collaboration, communication, and coordination among a network of diverse stakeholders (Conservation Priority 1). As reviewed in Chapter 12, these interested and affected parties range from nature educators to staff in different governmental and non-governmental bodies to community members to funders to content creators for media outlets to academics and citizen scientists. Although a daunting task, the creation of a formal network of such bat stakeholders has the potential to support and greatly advance bat conservation through a united front for the benefit of India's people, bats, and thriving ecosystems.

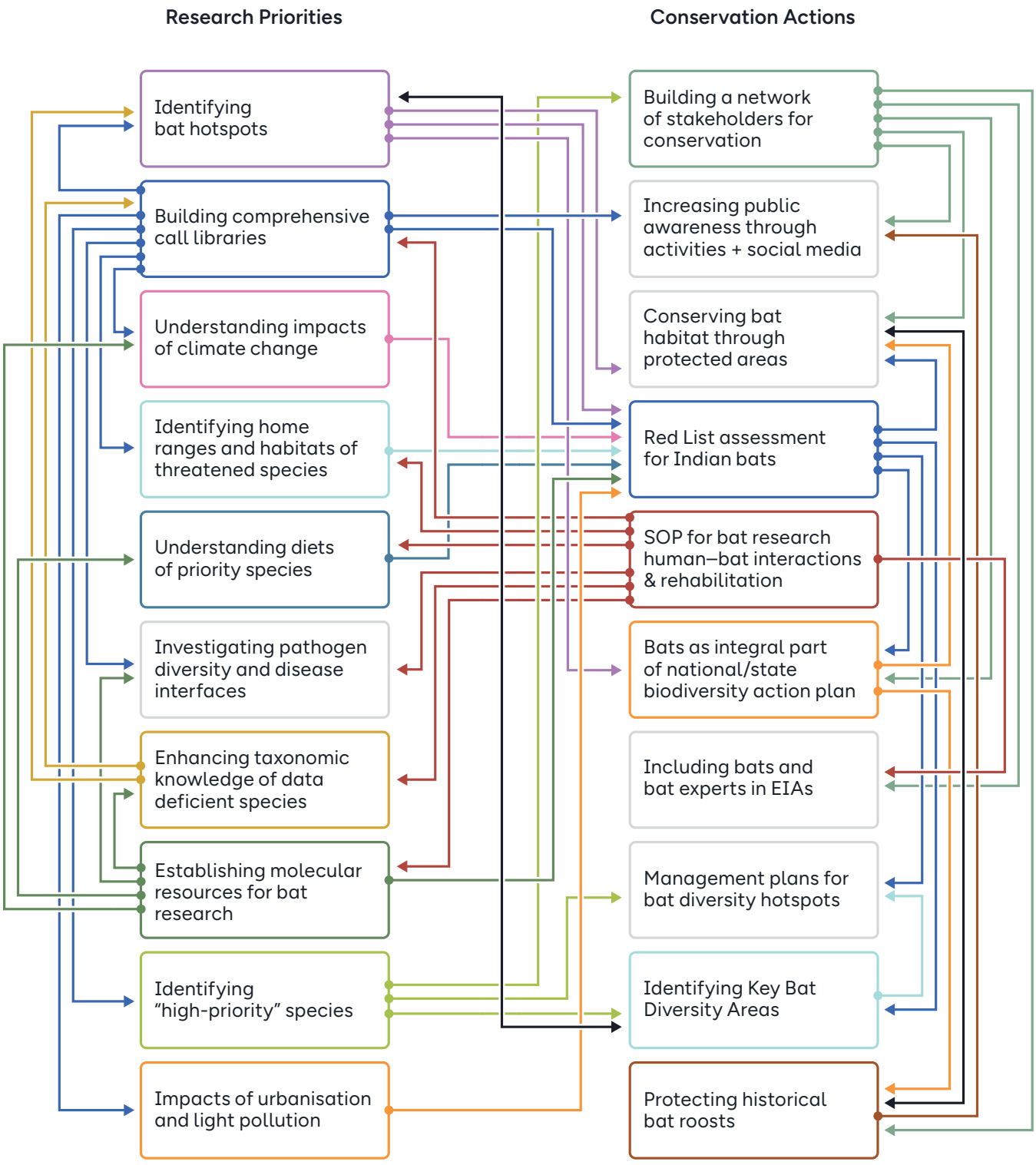

Figure 16.1 Links between the top ten conservation action and research priorities defined by the State of India's Bats (2024–2025) project.

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