Article

Expanding the uptake of conservation technology: insights from efforts to share conservation bioacoustics capacity in Indonesia and Malaysia

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Abstract Passive acoustic monitoring (PAM) of terrestrial habitats has grown exponentially over the last three decades, given recent technological advances and the utility of this approach in providing information on acoustically active animals, their habitats, and human activities across large spatial and temporal scales. Yet, just 1% of PAM studies were conducted in Southeast Asia, despite the region's global biodiversity importance. Both equipment availability and technical expertise are major constraints limiting the development of PAM in the region. To address this gap, we developed a capacity-sharing programme to support emerging practitioners in the use of PAM in Indonesia and Malaysia through equipment, training, mentoring, and networking. This paper describes the programme's design, development, implementation, and evaluation, and provides a detailed roadmap of our approach as well as a repository of training and assessment materials we developed across two cohorts of this year-long, in-depth programme. Utilizing quantitative and qualitative approaches, we assess the programme's strengths and weaknesses as well as its impacts on the knowledge, attitudes, and practices of its participants. Here, we provide an evidence base to demonstrate the positive impact of pairing technology with extended engagement through training, mentoring, and networking activities. We also provide practical resources for scientists and

practitioners across the globe to develop successful capacity-sharing programmes in emerging conservation technology fields.

Keywords Capacity Building, Capacity Development, Collaboration, Conservation Technology, Equity, Knowledge Transfer, Programme Evaluation, Training Impact

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Introduction

In the last 50 years, scientists have documented a catastrophic 73% decline in the average size of monitored wildlife populations, with the most significant drops in Latin America and the Caribbean (95%), Africa (76%), and Asia and the Pacific (60%), reflecting widespread but uneven impacts across regions and taxa (WWF, 2024). In light of the post-2020 Global Biodiversity Framework and the Sustainable Development Goals, it is clear that the global community needs to substantially improve our capacity to monitor wildlife and mitigate threats to biodiversity (Lahoz-Monfort et al., 2019; Convention on Biological Diversity, 2020). Recent advances in conservation technology have revolutionised scientists' ability to collect and analyse data at spatial and temporal scales needed to achieve conservation goals (Gottschalk et al., 2005; Steenweg et al., 2017; Sugai et al., 2019; Lahoz-Monfort et al., 2019; Tuia et al., 2022). However, most applications capable of addressing such scales are concentrated in the Global North (Darras et al., 2025). This pattern raises concerns about the potential for access to technologies and artificial intelligence to exacerbate scientific inequalities in the Global South (Murray et al., 2025).

The need for improved technical capacities emerges as a cornerstone of effective conservation strategies (Snaddon et al., 2013; Hahn et al., 2022). In a global analysis of protected areas, increased capacity – measured as adequate resources for a sufficient number of trained staff for effective management – was positively correlated with increases in animal abundance (Geldmann et al., 2018). While there is consensus that an increased emphasis on strengthening conservation technology capacity is essential to achieve a sustainable future (IPBES, 2024), addressing the existing gaps requires a robust approach that enhances the abilities of individuals, organisations, and communities to access, use, and share conservation technologies (Osei et al., 2024). Crucially, effective capacity building requires a systems-based approach that considers the broader context in which the programme operates (Porzecanski et al., 2022).

The uptake and use of emerging technologies have not been uniform (Sugai et al., 2019; Mugerwa et al., 2024). From the user perspective, the main barriers to the uptake in conservation technologies are upfront costs, necessary technical skills, and time to learn new technologies (Speaker et al., 2022). Further, end users from developing [sic] countries are more likely to report financial constraints when compared to developed [sic] ones, and female respondents more likely to be constrained by technical skills than males. Altogether, evidence suggests that the high cost of technologies along with a lack of expertise to process big datasets are major hurdles for conservation practitioners and academic researchers to implement innovative technical solutions for conservation problems (Hahn et al., 2022).

While the use of camera traps to monitor wildlife in protected areas has become ubiquitous across the globe (Chen et al., 2022), passive acoustic monitoring has been more inconsistently implemented, despite the strong potential of the technology and recent advances in efficiency and affordability (Kahl et al., 2021; Stowell, 2022). Passive acoustic monitoring (PAM) relies on autonomous recording units to monitor acoustically active species, their habitats, and their threats, providing information on temporal patterns of occurrence across national and regional scales (Swider et al., 2022; Sethi et al., 2024; Wood et al., 2024). While availability and accessibility have improved greatly in recent years, the use of PAM still requires field-specific expertise and training, and significant resources to acquire the equipment and analyse and store the data, which is often lacking in most parts of the globe, creating major obstacles for local implementation. For instance, a review of seven decades of bioacoustics research in Africa found that the majority of authors (74%) were non-African affiliates (Becker et al., 2022). Similarly, a global review of terrestrial PAM research between 1992 and 2018 showed that only 25% of 460 studies were conducted in the tropics – and just 5 in Southeast Asia – despite the high potential for PAM to address critical conservation needs in these high-biodiversity areas (Sugai et al., 2019).

Capacity-building efforts in PAM, and bioacoustics more broadly, have taken a variety of approaches. Some provide intensive engagement, such as the week-long Sound Analysis Workshop in the K. Lisa Yang Center for Conservation Bioacoustics (formerly Bioacoustics Research Program; hereafter, Yang Center) which, from 2007-2020, provided in-person training for 463 participants travelling from 43 countries. More recent efforts have included skill-building webinars (e.g., Bioacoustics & AI 101, 2024), and equipment grant programmes (e.g., Wildlife Acoustics, 2025). Online communities such as WILDLABS (WILDLABS, 2025), the Bioacoustics Stack Exchange (Bioacoustics Stack Exchange, 2025), and the African Bioacoustics Community (African Bioacoustics Community, 2025) have created digital spaces where practitioners can interact, share knowledge, and develop resources. Yet, to our knowledge, there have been few multi-year, sustained initiatives focused on PAM. As a notable exception, the Elephant Listening Project at the Yang Center has led a mentorship program in the Republic of the Congo since 2022, which has helped local researchers to conduct their own PAM projects and lead regional training workshops.

Although most United Nations agencies have adopted the term “capacity development” (Convention on Biological Diversity, 2020), this term does not clearly differentiate one-way knowledge transfer from two-way exchanges of expertise within learning initiatives. Here, we adopt the term “capacity sharing”, defined as the active collaboration between partners towards shared learning and research objectives (Lezak, 2024). Our approach to capacity sharing acknowledges that historical and contemporary forces have shaped global disparity in resource access and

environmental vulnerability, and emphasises the need for active exchange between practitioners who hold a specific skill set and the communities with whom they work (Lezak, 2024). Capacity sharing recognises that all participants hold their own wealth of knowledge and expertise and works to shift power to local actors (Menashy & Zakharia, 2022).

Here, we describe the process for planning, implementing, and adapting a capacity-sharing programme designed to advance the regional use of PAM for conservation in Indonesia and Malaysia. The programme focused on addressing the gaps in access to innovative bioacoustics technology and training while promoting and supporting a network of local practitioners. This manuscript presents a thorough consideration of four main sections of the program: 1) an overview of the planning and implementation processes; 2) evaluation and indicators of teams' performances; 3) critical assessment of lessons learned; and 4) future directions. As a collaborative effort from a cross-section of coordinators and participants, we hope that this paper serves not only as an inspiration to, but also as a useful resource for, scientists and practitioners interested in international capacity sharing in emerging conservation technology fields.

Bioacoustics Equipment and Training Program: Objectives and Overview

The Bioacoustics Equipment and Training Program (BEAT) was designed to provide equipment, training, mentorship, and networking support to teams from Indonesia and Malaysia interested in implementing bioacoustics in conservation-oriented research projects (Fig. 1). Broadly, this programme had three main objectives: 1) guide participants through the development of core bioacoustics skills through training sessions that span the full pipeline of a PAM project; 2) collaboratively plan and implement a pilot project by providing recording equipment and sustained mentorship to achieve their project goals; and 3) foster a regional network of practitioners through virtual sessions and in-person symposia, creating opportunities for knowledge exchange and collaboration. Importantly, BEAT organisers did not define success for teams, but rather teams themselves defined their goals and chose their metrics of success.

Methods

Adaptive implementation of BEAT

Building on WME's and DJC's long-term and strong research networks in Indonesia and Malaysia, we readily identified in-country collaborators who had a strong interest in advancing bioacoustics research (see Acknowledgements). With these collaborators, we collectively drafted the request for proposals. The request for proposals for the first cohort (Jun 2022 - May 2023) was

announced in February 2022 during a webinar that featured researchers conducting bioacoustics research in Indonesia and Malaysia. For both the first and second cohorts (Nov 2023 - Nov 2024), the request for proposals was shared on social media (institutional and personal accounts for organizers, partners, and alumni) and via WhatsApp groups.

Recognising the strong benefits of engaging in mutual learning and sharing between mentors and mentees (Santy et al., 2022) and hoping to encourage cross-sectoral collaboration (e.g., across academic, non-governmental, and governmental groups), the programme explicitly emphasised a team-based approach. We aimed to support projects that were feasible in the one-year time frame, and that demonstrated strong relevance to species and/or habitat conservation. Each team received four SwiftOne recorders, two hard drives, eight SD cards, licenses for Raven Pro 1.6 (K. Lisa Yang Center for Conservation Bioacoustics at the Cornell Lab of Ornithology, 2025), as well as a sufficient stock of D-cell batteries.

Teams were selected following a proposal review process led by a selection committee including local collaborators and Yang Center members using an evaluation rubric that considered the feasibility of the project, conservation goals, the likelihood of bioacoustics to be adopted by their organizations, and the representation of underrepresented groups. Proposals were anonymized, scored, and ranked according to the rubric, and the ranking was discussed for consensus regarding the final selection. In Cohort 1, we received 16 proposals and funded eight teams and in Cohort 2, we received 21 and funded nine (Supplementary Table 1).

Throughout the programme year, monthly virtual trainings of 1.5 to 3 hours were scheduled for the mornings or evenings in Indonesia and Malaysia (evenings or mornings New York time). The training sessions, taught primarily in English, covered a series of topics from equipment introduction, survey design, sound characterization, bioacoustic analyses and machine learning tools. We set up a web-based learning management system in Canvas to host training materials where we could also share announcements, centralize administration (e.g., syllabus, schedules, and Zoom links), and encourage discussion and engagement across teams.

To ensure that teams had broader support for conducting their projects and implementing the content learned during the training sessions, teams were matched with researchers from the Yang Center, based on shared research interests and expertise. Teams met with mentors monthly on Zoom to discuss their projects. The first mentorship meeting followed a structured template for mentors to ensure that teams were able to operate all of the necessary tools, understood the logistics of the programme, and that both mentors and mentees had a shared understanding of their commitments to and expectations of each other. In the second meeting, mentors and mentees reviewed the team's proposal to refine the research questions, prepare protocols, and outline appropriate timelines and

outputs. Subsequent meetings were loosely structured; BEAT organisers provided a checklist for teams to complete and teams set the agenda based on where they most needed guidance and support. To emphasise peer-to-peer learning in mentoring meetings, we invited members of Cohort 1 to join as mentors to the newly selected Cohort 2 teams, with each team having three mentors: two from the Yang Center and one from their region.

For Cohort 2, we introduced a one-hour session to help participants revisit tools and techniques from the previous training session. These sessions were crucial for making the methods translatable to participants' individual projects. While they occasionally included structured presentations, they were more often open sessions used to demo software, troubleshoot challenges, and work through questions as participants applied new skills to their work.We integrated fun challenges using Kahoot! (Kahoot!, 2025) as an engaging way to begin our training sessions and reinforce important concepts.

To align communication practices with regional norms, we created a WhatsApp group for each cohort as well as one for each team-mentor pair, where participants could more quickly share updates and ask questions. Networking formed a central component of BEAT. Drawing inspiration from the African Bioacoustics Community conference, we planned to organise an in-person conference at the end of the programme. In November 2023, this vision materialised with the inaugural Symposium for Indonesia–Malaysia BioAcoustics (SIMBA, Yogyakarta, Indonesia), co-organised by the Yang Center and partners at Universitas Gadjah Mada and Universiti Malaysia Terengganu (see acknowledgements). The symposium convened 105 participants from 44 organisations, including universities, research agencies, NGOs, and government bodies. The majority of attendees were members of BEAT Cohorts 1 and 2. For Cohort 1, the symposium was a capstone event, where representatives from all 8 teams delivered 13 presentations about their bioacoustics research. For Cohort 2, it marked the beginning of their training program and provided an opportunity to build connections with other teams.

Additional opportunities for engagement and networking emerged when monthly office hours morphed into a social hour (*jam sosial*) where participants could informally share their experiences and challenges using their native languages. In late 2023, WME, DJC, and BG began organizing a special issue focused on PAM in Indonesia and Malaysia (in which this paper appears). We invited members of Cohort 1 to contribute original research articles, participate in collaborative papers on particular themes, or serve as editors.

Programme evaluation framework

We designed and implemented a diverse series of assessment and evaluation tools across two cohorts. At the start of the program, we used quizzes to evaluate and compare participants' knowledge of the material before and after training sessions. The quizzes tended to start the sessions on a low note, and were quickly discontinued. We moved to a more interactive format to encourage peer-to-peer exchange and more naturally surface areas of confusion among participants. We opened breakout rooms and created digital whiteboards (Jamboards) with discussion prompts asking participants to share something they learned and something they were still unclear about, encouraging interaction across teams and creating a primary place for feedback and conversation, which provided instructors with a deeper understanding of how participants were engaging with the material and feeling about their experiences in the programme. During Cohort 1, we collected 10 Jamboards during breakout room discussions on Zoom, six of which are summarized in Table 2.

To assess the three primary objectives of BEAT to achieve 1) growth in participants' knowledge and confidence across the full PAM pipeline; 2) progress toward project goals; and 3) strength of community connection), we conducted anonymous pre- and post-programme surveys administered in Qualtrics. The surveys also collected demographic information from respondents (e.g., age, education level, prior bioacoustics experience) as well as a mix of open-ended, Likert scale (1-5), and multiple-choice questions (Supplementary Material 1). The pre-programme anonymous survey did not use a unique respondent identifier, so we could not track changes at the individual level. The survey was administered to participants around the first training session in July 2022 and included 18 questions related to confidence in different aspects of PAM, challenges and opportunities in aligning PAM with their personal and organisational goals, and aspirations to become a PAM mentor within their community. The post-programme anonymous survey was administered immediately following SIMBA in November 2023 and included 28 questions, including questions repeated from the pre-survey to allow for pre-post comparisons. An additional self-assessment was applied to assess participants' improvement in areas such as contributing to a PAM project, developing conservation strategies, increasing their professional network, seeking guidance on PAM issues, mentoring others, and conducting research.

In October 2024, we gathered information about the continuation of Cohort 1's involvement in bioacoustics-related projects, outreach activities, presentations, and mentorship efforts since the start of their experience in BEAT. DO and BG prepared a structured Google Form comprising 13 questions to survey teams from Cohort 1 (Supplementary Material 1), which were distributed to participants from Cohort 1 by email and WhatsApp.

We also gathered richer qualitative information about the participants' experiences in September 2024, with co-authors RO and JAS who were participants in the first cohort of the BEAT program, conducting interviews in Bahasa Indonesia with 14 participants from both cohorts (Table 1). We endeavoured to collect at least one interview per team, focusing on team members who were most active in the program across a range of activities (attended training and mentoring meetings, SIMBA, etc.). The interviews were conducted online via Zoom, lasting between 30 to 45 minutes. We focused on participants' experiences during BEAT, covering topics such as motivation, challenges, and key takeaways. Prior to the interview, participants were contacted via WhatsApp or email to obtain their approval, and a consent form was sent for their review. Each session was recorded in both video and audio formats, with Zoom's transcription feature used to generate a transcript. The interview guide is provided in Supplementary Material 1. These interviews were transcribed by the interviewers and the anonymised transcripts were shared with WME to help with coding and analysis. We identified key quotes and coded interviews by nine categories (motivations, hopes, challenges, highlights, future plans, biggest needs, key applications, key parties, and suggestions for the future of BEAT).

Results

Pre- and post-programme surveys

At the start of the BEAT program, most participants in Cohort 1 (14 of 18) reported no prior experience with PAM. However, they expressed strong confidence in their general scientific research skills, with 94% indicating confidence or high confidence in 'interpreting scientific manuscripts' and 72% in 'designing a study' (Fig. 2). In contrast, 33% reported neutral or low confidence in 'interpreting manuscripts in English' and 'understanding spoken English'.

We expected that improvements in PAM skills, networking, and mentoring would be reflected in shifts from low and neutral responses to higher ones between the pre- and post-surveys. This pattern was observed across most items. For core PAM technical skills—such as field deployment, data analysis, and general problem-solving—65% of participants reported feeling confident or very confident by the end of the program. Overall, lower scores declined while higher scores increased across nearly all PAM-related questions (Fig. 3). Post-survey self-assessments also showed strong gains: most participants indicated that the program substantially improved their 'ability to contribute to a PAM project', 'inform conservation strategies', and 'seek guidance on PAM-related issues' (Fig. 2-3). 'Motivation to use PAM' remained high throughout, with over 80% of responses selecting the highest rating at both time points (Fig. 3).

Confidence gains were especially strong in questions related to the PAM community and professional networks. The largest increases were seen in participants' sense of access to a PAM support network, awareness of PAM applications in conservation, and feeling part of a PAM community—each of which had over 75% of respondents selecting the highest confidence rating by the end of the program (Fig. 3). A similar pattern was observed in post-survey questions about professional networks and applying PAM to a range of conservation challenges (Fig. 2).

Conversely, confidence in 'writing a scientific paper' and 'communicating results in non-written formats' declined at the "Very confident" level, with approximately one-third of participants selecting this option in the pre-survey and none in the post-survey (Fig. 3). Post-survey responses shifted toward both "Confident" and "Neutral". Similarly, self-assessed confidence in 'conducting research and publishing' also moved modestly toward the middle of the scale (Fig. 2). These topics were not explicitly covered in our program but are considered critical for participants to effectively communicate their findings, and are therefore important topics to address in the future (see section Lessons learned).

Participants reported increased preparedness to serve as mentors, with responses shifting toward higher levels of agreement across multiple indicators. Interest in serving as a local mentor was already high and increased further by the end of the program (Fig. 4). In self-assessments, no participants agreed that they had 'adequate knowledge and skills' to be a mentor at the start, but over one-third did so in the post-survey (Fig. 4). Participants also more strongly agreed that they had the tools and resources to be a mentor, and about the benefits of mentoring for the conservation community (Fig. 4). Additionally, questions about how PAM could benefit their peer community, support conservation in local communities, and be valued by organizations remained consistently high before and after the programme (Fig. 4).

Finally, post-survey questions related to the symposium illustrated its positive impact: 75% of respondents selected the highest rating for 'improving connections to the regional bioacoustic community' and increased 'knowledge of PAM applications'. Additionally, 87.5% indicated a high likelihood of using PAM in future work, and 100% reported a strong likelihood of collaborating with other symposium participants (Fig. 4).

Survey of outputs from BEAT participants

Six of eight teams responded to the follow-up survey of Cohort 1, and their responses revealed strong engagement in presentations, publications, training, and community outreach (Supplementary Material 1). The teams delivered 13 presentations about their BEAT projects at

events and conferences, including SIMBA, the Brazilian Primatological Society Congress, and Cornell's Migration Celebration. They also led 7 bioacoustics workshops and other training activities, engaging more than 70 participants including university students and staff from local NGOs and national parks. At the time of the survey, one article had been published on research conducted during BEAT (Ong & Shahrudin, 2022), another was in revision and has since been published (Loo et al., 2025), while an additional 13 articles were in preparation, including several submissions for this special issue. The participants also led their own mentorship efforts, guiding 15 individuals from outside the program. Across 22 outreach activities, they engaged approximately 325 participants from high school students to local community members, through diverse activities, including a mindfulness session with a soundtrack of nature and gibbon songs.

Semi-structured interviews

Motivations and hopes for joining BEAT

Interview respondents represented a cross-section of participants across both cohorts, career levels, sectors, and nationalities (Table 1). A summary of their coded responses about their motivations, experiences, and future goals is reported in Table 3. The majority of respondents (86%) indicated their motivation to join BEAT to learn about bioacoustics as a new field, emphasising their excitement about mastering a new technology. Respondents told us that,

> *"Bioacoustics is a new field in Indonesia, making participation in the BEAT programme an exciting opportunity to learn about innovative, non-invasive methods for animal research. Another expectation is that this advanced technology allows observers to collect data by deploying the equipment in the field, where it can automatically gather data without constant human presence."*

> *"Bioacoustics is relatively new, especially in Indonesia, and it is closely related to our team's previous research fields, which focus on ecology, wildlife behaviour, and the use of bioacoustic approaches. It is actually one of the breakthroughs that strengthened our research. So, one of our goals in participating here is to enhance the research we have conducted before, using cutting-edge technology."*

All respondents identified research goals involving the identification of particular sounds to confirm the presence of specific species and/or compile a list of the species at their site(s). Of the respondents who had completed the program, half noted that their goals were fully realised in the

program, whereas a third noted only partial fulfilment (one emphasising ongoing analyses). One respondent noted that their original goal was not met but that new opportunities emerged,

> *"One of the ultimate goals was to identify each individual's voice. That has not been achieved because…we haven't had the chance to learn that yet… However, new opportunities emerged, such as passing on the knowledge by training students and sharing data for their research. This means more Indonesian students get exposed to and learn this new technology."*

<u>*Experiences in the program*</u>

We asked respondents to share any challenges they had experienced during the programme and in the execution of their projects. Most (64%) noted that they struggled to find the time for the training sessions, three highlighting the challenges due to time differences between the U.S. and Southeast Asia, and two others mentioning the long duration of each session. Other major barriers included language barriers (43%) and internet bandwidth for joining sessions on Zoom (36%). Both fieldwork and data analysis challenges were experienced by 57% of participants in the execution of their projects. The following quotes highlight a range of participant experiences,

> *"The lesson I learned from BEAT training is the need to commit to the time requirements right from the start. I realised that, even with other work priorities, I needed to make attending the BEAT training a priority on my schedule."*

> "*When it comes to analysing data, learning scripts, and using the software, it's definitely a bit challenging for us to understand within a short time period. It's also not easy to fully grasp the knowledge because of language barriers."*

> *"My team consists of fieldworkers and one advisor. The field team focuses solely on technical tasks, while the advisor only receives reports. As a result, I lack resources for knowledge-sharing and conducting data analysis"*

We also asked them to share the most important thing they learned, achieved, or developed during BEAT. The majority (86%) pointed to the knowledge of bioacoustics and/or the importance of PAM as a valuable tool. Half mentioned the opportunity to share knowledge, while 36% noted the network of practitioners across the two countries, and 29% pointed out the large quantity of data accumulated during their projects as highlights that can be used for more research and practice beyond the program. One respondent highlighted the potential of using their sound recordings to connect to the arts,

366 *"I can apply the bioacoustic results as a tool to bridge science to the public by*
367 *collaborating with artists through sounds to develop creative materials like song."*

368 During the interviews, several respondents reflected spontaneously on aspects of the
369 programme that they had found particularly useful or supportive. They shared insights into the
370 materials and approaches they experienced in the program, including:

371 *"The learning environment built in the BEAT Program is supportive, which makes us*
372 *comfortable to ask, not only during training but also in mentoring sessions."*

373 *"The module guides are easy to read and quite helpful. You can learn the guide first before*
374 *training/mentoring session"*

375 *"This programme has classes and regular practice to learn new technology. The trainer*
376 *really guided me through the topic. Not all funding/grants follow up with capacity sharing."*

377 *Future aspirations with bioacoustics*

378 We asked respondents about their interest in using bioacoustics in future research and what
379 would help them succeed. All respondents told us they continue using bioacoustics for a range of
380 activities, including expanding to more species and sites (57%), training students and/or additional
381 team members (50%), using BirdNET to create detectors for sounds of interest (29%), as well as
382 conducting outreach and developing sound libraries (14% each). To succeed, they told us they
383 would most benefit from a forum where they could exchange ideas and knowledge about
384 bioacoustics (34%), a well-trained team (29%), collaboration and support for publishing their
385 research (25%), more training for analysis (8%), as well as more research equipment (4%). One
386 respondent highlighted this interest and need for a strong collaborative network going forward,

387 *"The question is, after we achieve our goals, what's next? Bioacoustics has opened our eyes*
388 *to the fact that it's more than just the data we initially aim to collect. There's a wealth of*
389 *additional data gathered simultaneously, which requires further analysis. That's why*
390 *creating a platform for collaboration between bioacousticians is essential to move*
391 *forward".*

392 We additionally asked respondents to describe what is most needed to advance conservation
393 bioacoustics in their region or community. They told us that training (30%), collaboration (24%), a
394 discussion forum (20%), and funding opportunities (13%) would most help. Better technology and
395 rechargeable batteries for recorders (7%), as well as improvements in permits and policy (6%)
396 would also be helpful. The people we interviewed identified several key applications of

bioacoustics for conservation, including species recognition and/or species richness assessment (56%), threat detection (17%), population density estimation (11%), machine learning (i.e., automated detector development) (11%), and breeding behaviour (5%). They identified key parties who could make this information actionable, including local governments (27%), universities and research centres (21%), ministries (17%), national parks (14%), local communities (14%), and the private sector (7%). One respondent explained how bioacoustics could be used to support protected area management,

> *"Our project was located in the national park, and the outcomes we produced should ideally translate into management recommendations for species and their habitats within the area, as that aligns with the national park's main responsibilities. However, for areas outside conservation zones, we could involve a broader range of stakeholders to address the challenges and implement solutions collaboratively."*

Shaping the future of BEAT

At the end of each interview, we asked respondents to share ideas for future training and mentoring programmes to support conservation bioacousticians in the region. Notably, all interviewees told us they were interested in being involved in BEAT going forward. Their recommendations included continuing the annual year-long training programme (24%), peer training to minimise the language barrier (24%), more intense mentorship (17%), advanced training in machine learning (14%), the development of a discussion forum (14%), and communication and/or publication (7%). Two respondents told us,

> *"It would be good if the next BEAT program offered training with different levels. For instance, there could be a more advanced track for those who want to delve deeper into bioacoustics and a lighter, more introductory track for beginners."*

> *"If possible, in addition to training in communication, there is collaboration for publications, particularly by involving mentors. This would certainly enhance the outcomes of the analysis from the BEAT project we are working on."*

Discussion

Here, we described the development and implementation of BEAT, a year-long capacity-sharing programme focused on facilitating the application of PAM by practitioners in Indonesia and Malaysia. Our analysis generated multiple insights into the effectiveness of the programme and the way forward to pursue equipment, training, mentorship, and networking goals to promote a regional

community of conservation bioacoustics practitioners. The assessment of the programme based on anonymous surveys indicated strong improvements in participants' self-assessment of their ability to design and conduct a PAM study and to access the tools and resources needed to mentor others. They also increased their access to a PAM support network and their awareness of the use of PAM in conservation use as well as its potential benefits to their community. Interviews highlighted the usefulness of training tools, supportive networks, and mentorship. Allowing teams to set their own goals kept motivation high and enabled flexible project adaptation, leading to high satisfaction even when some goals were not fully realized.

This collaborative model highlights our capacity-sharing approach that sought to advance mutual learning, adaptive problem-solving, and shared growth across participants, organizers, and mentors. Additionally, BEAT participants' field-based experiences and knowledge advanced and improved tools and approaches for teaching and implementing PAM for a wider community – making BEAT a test kitchen for the development and refinement of hardware and software at the Yang Center. For instance, the development of a graphic user interface of BirdNET Analyzer (Kahl et al., 2021) was fast-tracked to help BEAT teams develop custom detectors. Hardware challenges reported by participants – such as water intrusion and damage – led to experimentation and refinements to the SwiftOne recorders as well as guides for repairing and replacing damaged parts. Deep engagement with this user-group also inspired upgrades to several applications that enabled support of Malaysian and Indonesian languages (e.g., Swift Configuration Utility). BEAT instructors and mentors benefited from participants' hands-on knowledge and insights into target species and ecosystems, cultivating deeper understanding of the region's conservation challenges and enhanced sensitivity to locally-tailored solutions. Although partners, organizers, and mentors were not includided in the initial evaluation design, our experiences highlight the importance of including assessments of these multi-directional benefits for future initiatives.

Collectively, our experiences and assessments point to some emergent successes. BEAT recruited motivated participants from mixed career stages and sectors within and among teams, facilitated networking and support. Despite BEAT offering limited financial resources (e.g., few recorders per team, and staff time or fieldwork costs were not provided), the level of engagement and retention rate have been very high, and many teams cultivated opportunities to transfer knowledge beyond BEAT through cross-cohort engagement. Cross-cohort engagement thrived, with alumni mentoring new teams and developing and presenting training materials. The special issue in which this article appears, "Shaping the future of PAM in Malaysia and Indonesia" is also a visible demonstration of BEAT's success. A collaborative capacity-sharing activity itself – with

editors and authors spanning regions, sectors, disciplines, and career levels – the issue celebrates the commitments, experiences, and discoveries of this programme.

Challenges and areas for improvement

BEAT was designed and delivered by a team of academics who collectively held years of expertise in conducting and teaching bioacoustics research. At the same time, BEAT challenged many of academia's existing conventions and we learned – while doing – that the time required to develop, plan, and execute such a programme appropriately and effectively was much higher than we had anticipated. When BEAT was launched and the first assessments were made, we quickly learned that the measurement of success would require a thoughtful and comprehensive strategy, both for the participants'projects and the programme as a whole. As a result, many of our assessments were designed and adapted while the programme was underway.

Some areas for future attention became clearer based on our surveys. While confidence to analyse PAM data was higher compared to the beginning of the program, many haven't reached the highest levels of confidence. Participants' engagement was also limited by technical barriers related to hardware (e.g., computers that could not effectively run software or process large datasets), poor internet connection that constrained participation on Zoom, and differences in time zones and language – as well as competing demands from full-time jobs. Survey responses also showed that BEAT did not improve participants' confidence for writing and other forms of communication about their findings.

Implementing the programme was also not without its challenges. For each cohort, the cost was approximately $25-30,000 USD, including equipment and symposium travel. The more substantial cost was the investment of Cornell staff time, with 2-4 people spending 2-4 months of effort across the course of the year (developing request for proposals, selecting teams, creating and delivering training materials, planning and attending symposia, etc.). An additional 16 mentors (8 Yang Center postdocs and staff as well as 8 regional mentors from Cohort 1 and beyond) invested 20-80 hours/year in mentorship meetings and office hours. The programme also received substantial administrative support, including for purchasing and shipping equipment and developing legal documents. While some of these activities became more streamlined with time, these investments represent essential and substantial components.

Language and cultural differences are baseline challenges often difficult to detect from a heterogeneous group, with different levels of comfort with the language. The pre-programme survey indicated that 33% of the participants had low confidence in understanding spoken English.

The use of translated closed captions (Zoom feature) and bilingual slides were later programme additions to mitigate language barriers. Further, constructive feedback collected during unmoderated breakout rooms or 'social hours' provided invaluable guidance on which concepts or skills needed reinforcement and strategic adjustments.

Lessons learned and the future of BEAT

In a collaborative reflection, all authors identified the most important lessons we learned through our engagement in and assessment of BEAT. Together, we recognized that addressing gaps in PAM – and conservation technology uptake broadly – requires a sustained, collaborative, and holistic capacity-sharing approach from a deeply dedicated team. Careful planning, strong communication, patience, and flexibility are critical ingredients for successful collaboration across all aspects of the programme; this is especially important when working across career stages, sectors, nationalities, and languages. We believe that BEAT's blend of structured study, peer learning, and sustained mentorship were critical to participants' growth and retention. Mentors' flexibility as well as their cultural and language competency were key to participants feeling comfortable to take risks, ask questions, and embrace leadership roles. Also central to BEAT's successes were our solid and committed local partners, who provided critical guidance and counsel, and hosted key in-person events. The long-term commitments among all partners, coordinators, and participants are absolutely essential to continued growth and success of the programme and PAM across the region.

We initially conceived BEAT as a one-year programme during which participants would develop all of the skills needed for the full PAM pipeline. As the programme unfolded, we recognized the importance of sustained – even multi-year – engagement with these cohorts for ongoing support and training in developing and advanced topics (e.g., training custom models using machine learning). We also saw the huge potential for this community, which inspired efforts for more direct collaboration with folks in the region to develop programmes and materials. For instance, the Katharine B. Payne Fellows Program in Conservation Bioacoustics (Cornell Chronicle, 2022) was established in 2022 to support scientists to spend six months at the Yang Center to learn to teach and mentor others. The inaugural cohort included two fellows from Indonesia: one BEAT alumnus and another who was introduced to bioacoustics during a training workshop organized by another BEAT alumna.

Looking ahead, together with BEAT alumni and key partners, we are undertaking a co-creation approach to the planning, development, and evaluation of the third BEAT cohort. Together, we will define metrics of success for both instructors and participants and design aligned

assessment tools. With this next iteration, we hope to address many of the challenges and barriers, and to expand opportunities for building the skills and networks that are needed for long-term success. As leadership transitions to regional partners in the Global South, maintaining feedback loops will be essential to ensure technological development is appropriately situated in the physical, cultural, political, and economic contexts of this user base.

Conclusion

We have summarized the foundations, insights and lessons learned with the Bioacoustics Equipment and Training programme for Indonesia and Malaysia. To achieve our goals, we created a programme that i) provided training through virtual sessions that combined lectures and activities, ii) equipped teams with recording units to gather acoustic data while providing personalized mentoring to enure teams could successfully design and execute their individual projects, and iii) cultivated virtual spaces for teams to interact and collaborate and established the first regional bioacoustics symposium that fostered networking across cohorts.

Collaboratively designed by academic partners at three universities in the United States, Malaysia, and Indonesia, BEAT's flexible and iterative approach sought to center participants' experiences and goals. Whereas feedback collected throughout the programme helped guide and refine the format, content, and structure, pre- and post-programme surveys allowed us to assess changes in participants' knowledge, skills, attitudes, and PAM-related opportunities. Semi-structured interviews with a cross-section of participants drew out deeper insights into the strengths, weaknesses, and future needs of this programme and the region's emerging networks.

Author contributions A brief statement that specifies the contributions of each author (specified by their initials), in the following form: BEAT conceptualisation: WME, DJC, LBS; BEAT funding acquisition: LBS, WME, DJC, BG, LSMS; BEAT project administration: BG, LBS, LSMS, WME, DJC; study conceptualization and design: WME, DJC, BG, DO, RO, JAS; data collection: AO, JAS, DO, BG, WME; data analysis: WME, RO, BG, DO, JAS, LSMS; writing and editing: WME, DJC, BG, DO, RO, LBS, LSMS, JAS.

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Conflicts of interest 'None'.

Ethical standards This study was conducted in accordance with ethical guidelines and received approval from the Institutional Review Board (IRB 0148971) under requirements set by Cornell University. All participants provided informed consent prior to their involvement in the study, and steps were taken to ensure confidentiality and minimize any potential risks.

Data availability All evidence supporting our findings are available in the Supplemental Materials.

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684 TABLE 1 Summary of the number and proportion of interview respondents by cohort, gender,
685 education level, work sector, and years of experience

	Cohort 1		Cohort 2	
	N	%	N	%
Country				
Indonesia	5	36	6	43
Malaysia	1	7	2	14
Gender				
Man	3	21	5	36
Woman	3	21	3	21
Education				
Bachelor	3	21	4	29
Master's	2	14	1	7
Doctorate	1	7	3	21
Sector				
Non-profit	5	36	3	21
University	1	7	2	14
Private	-	-	2	14
Government	-	-	1	7
Years experience in sector				
≤ 1	2	14	1	7
2-5	1	7	3	21
6-10	2	14	3	21
> 10	1	7	1	7
Total	6	43	8	57

686
687

688 TABLE 2 Summary of Cohort 1 Jamboard discussions during Zoom training sessions.
689

Session	Jamboard topic	Sample text
Introductions & program overview	Icebreaker: What is your favorite animal? What sound does it make?	"Javan gibbons! The female makes beautiful great call!"
		"The Helmeted hornbill - maniac laugh call"
Digital audio basics & getting started with SwiftOne	Share something you've learned from the presentations	"Sampling rate must be >2X the highest frequency you want to record!! Lesson learned!!"
	Share questions or tell us what is unclear	"We are excited to know how to differentiate between species and look at what gain/sample rate is suitable."
		"In different areas (different noise level) should we set the settings differently? Is it OK to do so?"
Field practicalities & experimental design	Share something you've learned from the session	"Metadata is important"
		"Always bring spares"
	Share questions or tell us what is unclear	"Still confused about the white button, when should we use it?"
PAM fundamentals	Share something you've learned from the session	"Kahoot is fun. More questions please."
		"Scavenger hunt is fun."
	Share questions or tell us what is unclear	"How do I save selections in Raven"?
		"How can we visualise weeks of data?"
Half-way check-in	What do you think could be improved in the training and mentorship sessions?	"step by step tutorial and more slowly"
	Are there topics that have not been covered that you want to know?	"data analysis for sharing purposes"
Closing session	How would you summarize your experience in this program?	"Excited about the training but cannot fully absorb the knowledge and could not follow the training 100%, struggling a bit probably due to language barrier."
	How will you apply what you learned in your future work?	"Popularise bird songs to musicians for music in Malang"
	What is one piece of advice you would give to Year 2	"Suggestion for the mentor to demonstrate the process first, then participants follow in the breakout"

participants?	"Consider using rain protectors around your PAM equipment"

690 TABLE 3 Summary of coded responses to interview questions about program participants'
691 motivations, experiences, and future plans, disaggregated by cohort (14 total respondents)

	Cohort 1	Cohort 2	% respondents
Motivation			
trial new technology	4	8	86
study behavior	2	5	50
develop new skill	1	3	29
connect with bioacousticians	1	0	7
Hopes			
identify particular species	3	5	57
confirm species presence	3	4	50
identify individual sounds	2	4	43
biodiversity survey	1	2	21
Challenges			
time	3	6	64
field techniques	4	4	57
machine learning	3	5	57
language barrier	3	3	43
poor internet bandwidth	1	4	36
lack of human resources	2	3	29
high data volume	1	1	21
Highlights			
bioacoustics knowledge	3	8	79
knowledge sharing	3	4	50
PAM as a valuable tool	3	2	36
Indo-Malay network	4	1	36
lots of data	1	3	29
Future plans			
apply bioacoustics to new projects	4	4	57
train others	3	2	36
apply BirdNET to datasets	2	2	29
combine bioacoustics with other methods	0	3	21
outreach	1	1	14

create sound library	1	1	14

FIG. 1 Schematic of primary components of the BEAT programme, indicating key elements for each.

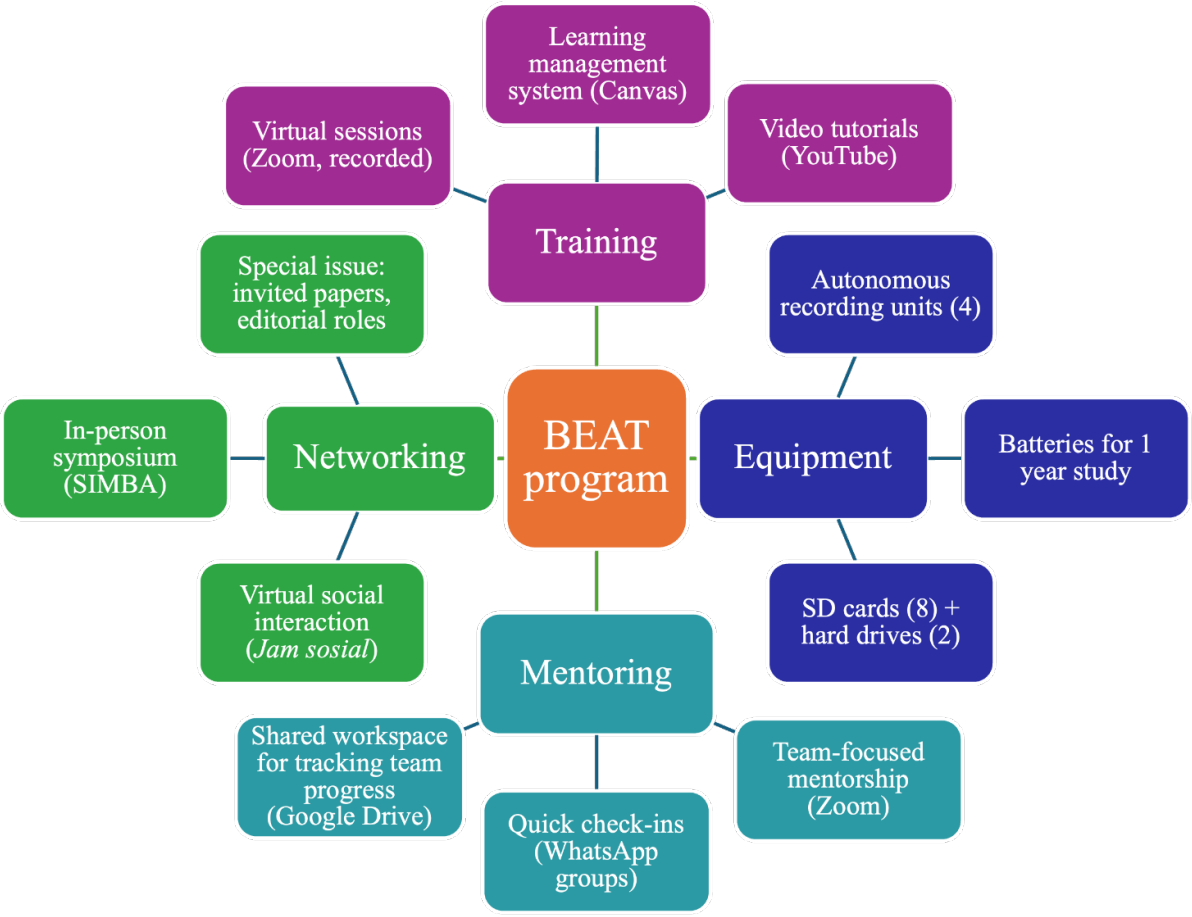


FIG. 2 Respondent scores from 1 to 5 (each rectangle represents one response) for unmatched questions applied in the pre- and post-programme surveys administered to participants of the first cohort of BEAT. a) Level of confidence at the start of BEAT related to interpreting manuscripts (native language and English), designing a scientific study and understanding spoken English, with scores representing 1 = Not confident, 2 = Slightly confident, 3 = Somewhat confident, 4 = Confident, to 5 = Very confident. Post-surveys self-assessments aimed at understanding. Level of improvement b) after BEAT related to aspects of conservation research and mentoring and c) following participation in the regional symposium, SIMBA, with scores ranging from 1 = no improvement at all and 5 = a lot of improvement.

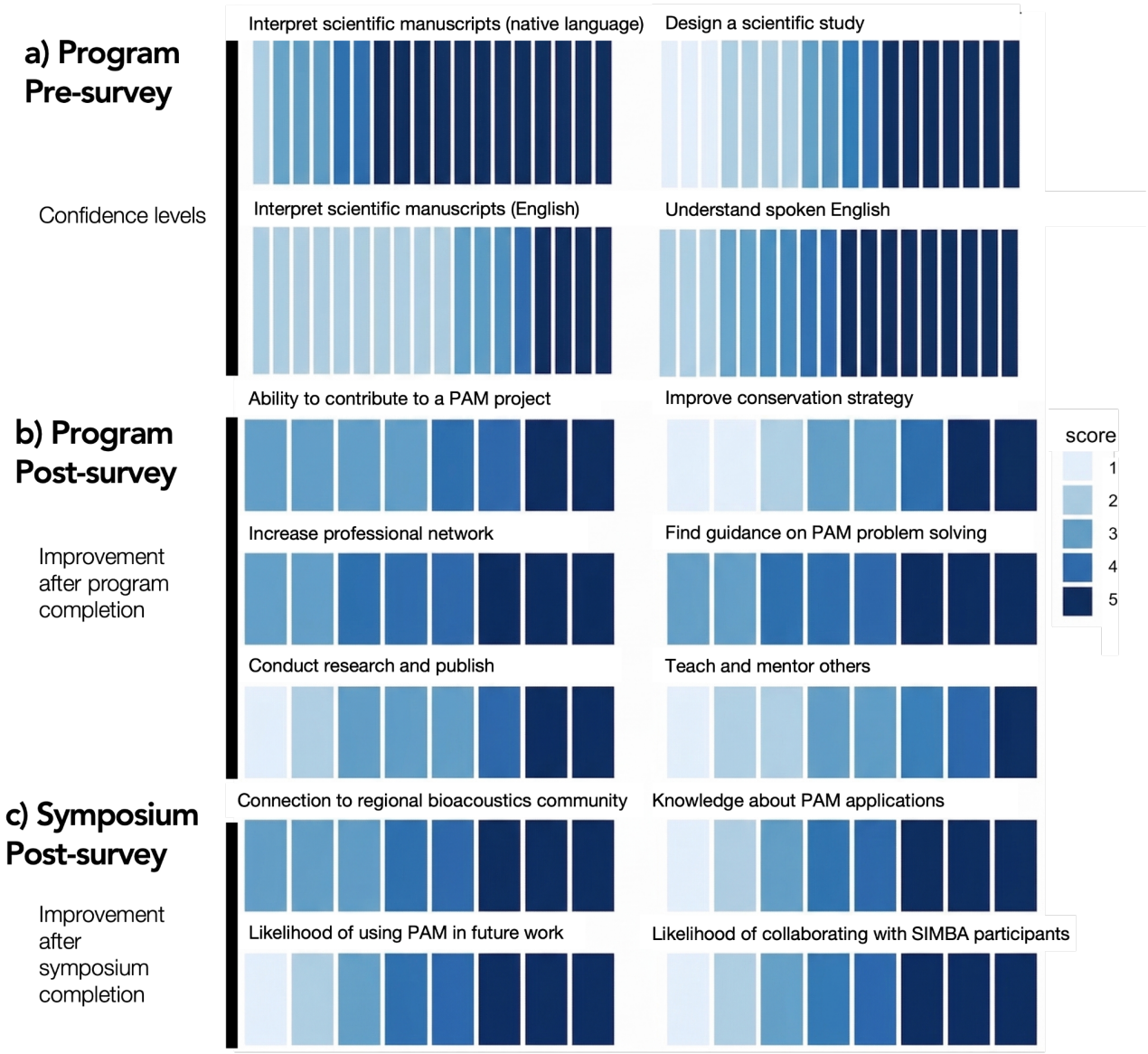


FIG. 3 Responses to matched questions from pre- and post-programme surveys distributed to the first BEAT cohort aimed at assessing confidence in different aspects of PAM research, problem-solving skills, and being part of a community. Confidence scores (a–d, l–m): 1 = Not confident, 2 = Slightly confident, 3 = Somewhat confident, 4 = Confident, 5 = Very confident. Agreement levels (f–k): 1 = Strongly disagree, 2 = Somewhat disagree, 3 = Neither agree nor disagree, 4 = Somewhat agree, 5 = Strongly agree.

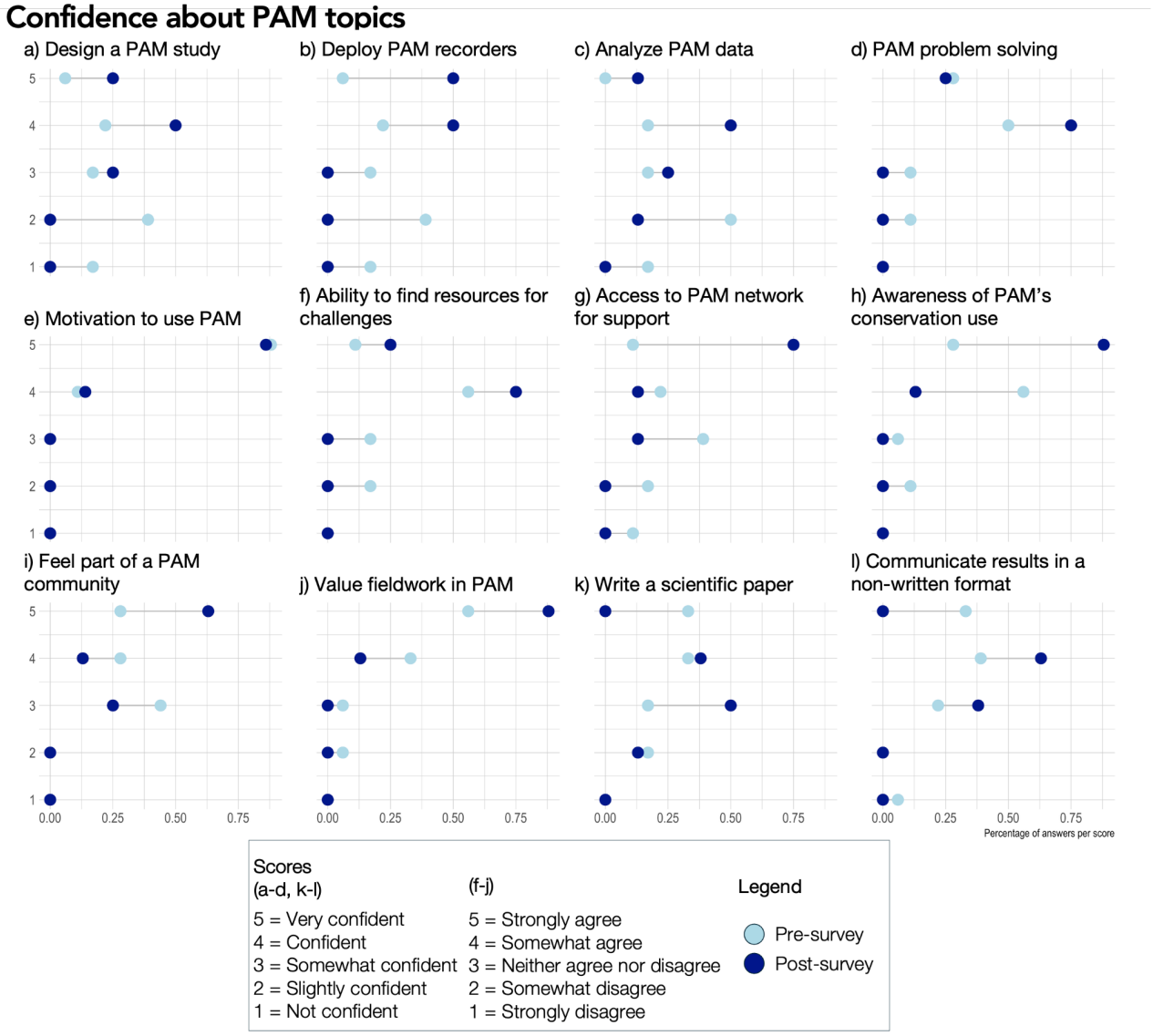
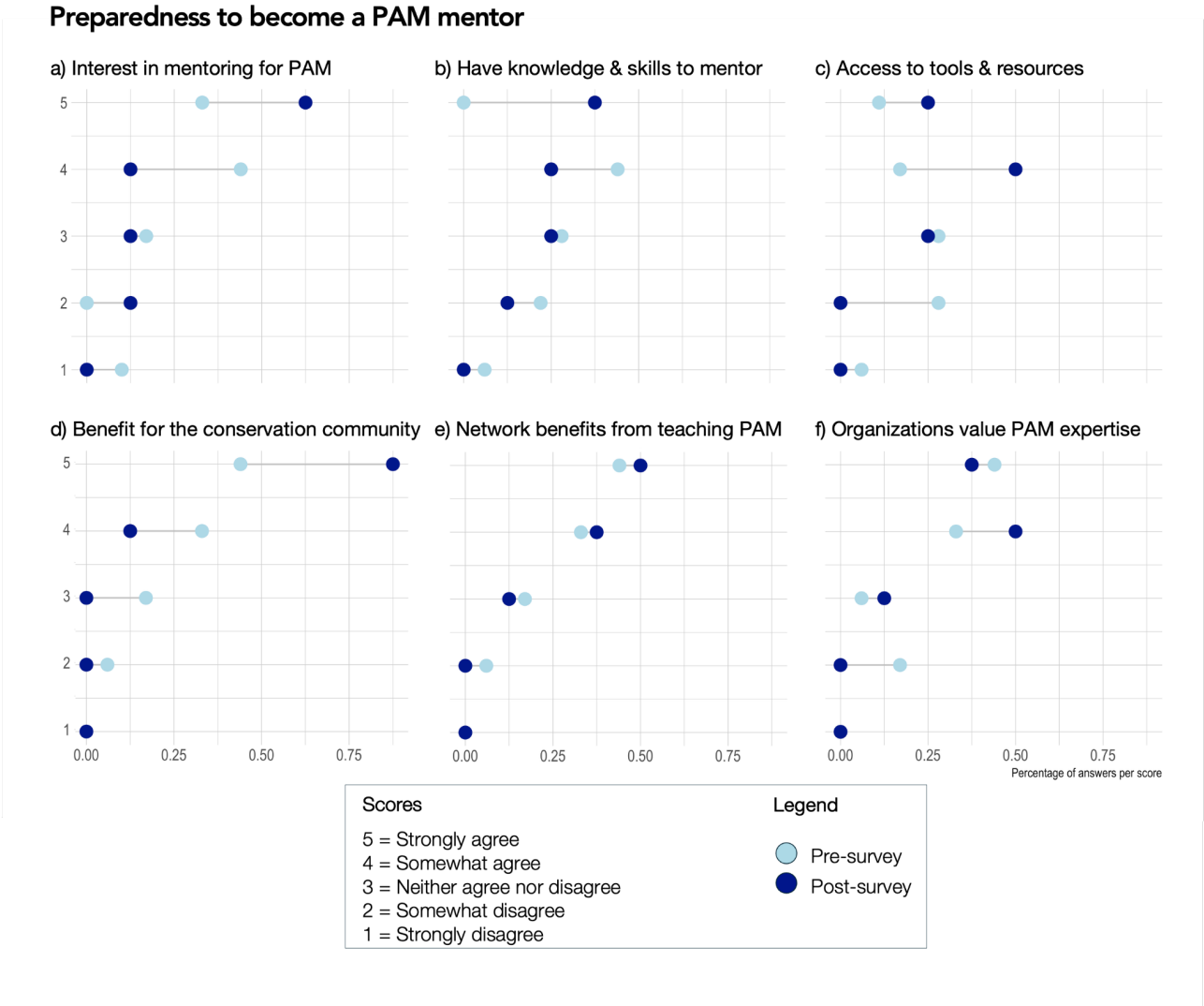


FIG. 4 Responses to matched questions from pre- and post-programme surveys distributed to the first BEAT cohort aimed at assessing their preparedness to mentor others in passive acoustic monitoring.



Reflections on a Conservation Bioacoustics Capacity Sharing Program in Indonesia and Malaysia: Assessments, Outcomes, and Lessons for the Future

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SUPPLEMENTARY MATERIAL 1 This supplementary material includes the following materials: questions administered during 1) pre-program, 2) post-program, and 3) team output surveys as well as 4) the interview guide.

1. Pre-Program Survey

Q1 What is your name? (If you wish to remain anonymous, please create a fake name for yourself that you will use in this survey and all future surveys and write it here instead of your name.)

Q2 What is your team name?

Q3 In what country will you be working?

Q4 Which of the following best describes your current position (check all that apply):

☐ Undergraduate student
☐ Master's student
☐ PhD Student
☐ Professor or lecturer
☐ Researcher or program manager at NGO
☐ Field work technician
☐ Other

Q5 For how long have you been using passive acoustic monitoring in your work?

☐ No experience yet
☐ < 1 year
☐ 1–5 years
☐ 5–10 years
☐ > 10 years

Q6 This part of the assessment relates to your confidence in different topics related to passive acoustic monitoring. The scale below goes from 1 to 5, with 1 being the lowest level and 5 the highest.

☐ Reading scientific papers in your first language
☐ Reading and understanding English
☐ Reading and understanding scientific papers written in English
☐ Designing a scientific study
☐ Designing a PAM study
☐ Deploying PAM recorders in the field
☐ Analyzing PAM data to answer a research question
☐ Writing a scientific paper
☐ Communicating to academics in a non-written format (podium, poster, etc.)
☐ Communicating findings of a study to relevant stakeholders in an informative way (i.e. local government, industry, park managers, community)

Q7 What are you most excited to learn about in this training program?

Q8 What other related or relevant trainings have you taken or are taking?

Q9 How does this training program fit into your organizational roles? Do you think this training and these new skills will be supported and recognized where you work?

Q10 Please evaluate the following statements:

1. Strongly disagree
2. Somewhat disagree
3. Neither agree nor disagree
4. Somewhat agree
5. Strongly agree

☐ I feel confident solving problems and overcoming obstacles that happen during a PAM study
☐ I know where to find online resources to help me when I encounter challenges
☐ I have a network of PAM practitioners I can ask for advice, support and guidance
☐ I am motivated to use PAM in my research and conservation work
☐ I am aware of how PAM can be used to address different conservation challenges in my region
☐ I feel part of a community of PAM practitioners
☐ I value the "team" aspect of PAM work

Q11 How do you envision using passive acoustic monitoring in your work now or in the future?

Q12 What are the major hurdles you anticipate for using passive acoustic monitoring in your work?

Q13 What are the biggest barriers to your success with passive acoustic monitoring? Please mark a point on the line from 0–100 where 0 is not a barrier at all and 100 is the biggest barrier.

☐ Research design capacity
☐ Research funding opportunities
☐ Data storage options
☐ Data analysis skills or tools

Q14 This part of the survey relates to being a PAM mentor in your community:

1. Strongly disagree
2. Somewhat disagree
3. Neither agree nor disagree
4. Somewhat agree
5. Strongly agree

☐ I am interested in becoming a mentor in PAM for others in my community
☐ I have the knowledge and skills to be a mentor
☐ I have the tools and resources to be a mentor
☐ Colleagues in my community can benefit from learning and implementing PAM techniques

▢ My community can benefit from implementing PAM techniques to address local conservation issues
▢ I am interested in continuing to do more PAM projects in the near future
▢ There are organizations around me that would value this work and my expertise in this topic

Q15 If you are interested in becoming a PAM mentor, what do you want / need to make that happen?

Q16 What kind of teaching, training, and mentoring activities would you be interested in leading or co-leading? Who would your target audience be for these activities?

Q17 Is there anything else you'd like to share?

Q18 Did you think this survey was too long?

▢ Yes
▢ No

2. Post-Program Survey

Q3 Unique Identifier Question 2: How many sisters do you have?

Q4 Unique Identifier Question 3: What day of the month you were born?

Q6 In what country are you working?

Q7 Age:

▢ Under 18
▢ 18-24
▢ 24-34
▢ 35-44
▢ 45-54
▢ 55-64
▢ 65 or older
▢ Prefer not to say

Q8 Gender:

▢ Female
▢ Male
▢ Prefer not to say
▢ Other

Q11 What is the highest level of education you have completed?

▢ Less than a high school diploma
▢ High school degree or equivalent

☐ Some college but no degree
☐ Associate degree
☐ Bachelor's degree
☐ Master's degree
☐ Professional degree
☐ Doctorate

Q12 Which of the following best describes your current position (check all that apply):

☐ Undergraduate student
☐ Master's student
☐ PhD Student
☐ Professor or lecturer
☐ Researcher or program manager at NGO
☐ Field work technician
☐ Other

Q13 Prior to the BEAT Program, for how long were you using passive acoustic monitoring in your work?

☐ No experience yet
☐ < 1 year
☐ 1-5 years
☐ 5–10 years
☐ > 10 years

Q15 These questions aim to assess the impact of the BEAT program. Please reflect on how much each of the following aspects has improved for you since the beginning of the program. Use a five-point scale where 1 represents no improvement at all and 5 represents a lot of improvement. To what degree did participation in the BEAT Program lead to improvement in each of these areas:

1. Not at all
2. A little
3. Moderately
4. Substantially
5. A lot

☐ Your ability to contribute to a PAM project (i.e. collect data, analyze data, design a study, interpret results)
☐ Your ability to contribute to an improved conservation strategy
☐ An increase in your professional network
☐ Seeking and receiving guidance on PAM-related issues
☐ Ability to teach and mentor others about PAM
☐ Ability to conduct research and publish

Q16 How many projects related to Passive Acoustic Monitoring (PAM) are you currently involved in? Please specify the number below:

Q36 Please briefly describe these projects below (i.e. monitoring lars gibbon population and distribution in Northern Sumatra):

Q17 In the past year, have you organized or taught any training activities (e.g. lectures, webinars, workshops, etc.) focused on bioacoustics? Please specify the number of workshops you've organized below.

Q37 Please provide a brief description of these training activities including the number of participants (i.e. Bioacoustics Webinar for 30 UGM Undergraduate Students in July, 2023).

Q27 How many individuals participated in your training activities over the past year? Please specify the total number below.

Q28 How many students or colleagues have you mentored in the field of bioacoustics over the past year (not including your BEAT team members)? Please specify the number below.

Q30 Could you specify the number of conferences or events, SIMBA included, where you have presented your research in bioacoustics?

Q14 This part of the assessment relates to your confidence in different topics related to passive acoustic monitoring. The scale below goes from 1 to 5, with 1 being the lowest level and 5 the highest.

1. Not confident
2. Slightly confident
3. Somewhat confident
4. Confident
5. Very confident

☐ Designing a passive acoustic monitoring (PAM) study

☐ Deploying PAM recorders in the field

☐ Managing large quantities of acoustic data

☐ Analyzing PAM data to answer a research question

☐ Using automated methods like machine learning to analyze acoustic data

☐ Writing a scientific paper

☐ Communicating to academics in a non-written format (podium, poster, etc.)

☐ Communicating findings of a study to relevant stakeholders in an informative way (i.e. local government, industry, park managers, community)

Q18 Please evaluate the following statements:

1. Strongly disagree
2. Somewhat disagree
3. Neither agree nor disagree
4. Somewhat agree
5. Strongly agree

☐ I feel confident solving problems and overcoming obstacles that happen during a PAM study

☐ I know where to find online resources to help me when I encounter challenges

☐ I have a network of PAM practitioners I can ask for advice, support and guidance

☐ I am motivated to use PAM in my research and conservation work

☐ I am aware of how PAM can be used to address different conservation challenges in my region ☐ I feel part of a community of PAM practitioners

☐ I value the “team” aspect of PAM work

☐ I am interested in continuing to do more PAM projects in the near future

Q31 Do you plan to do more bioacoustics research in the next year?

☐ No

☐ Yes, but it will not be a major focus

☐ Yes, it will be one of my main priorities

☐ Unsure

Q32 Do you intend to conduct bioacoustics training and mentorship opportunities in the next year?

1. No
2. Maybe
3. Definitely
4. Unsure

☐ Outreach

☐ Teaching

☐ Mentoring

Q22 This part of the survey relates to being a PAM mentor in your community.

1. Strongly disagree
2. Somewhat disagree
3. Neither agree nor disagree
4. Somewhat agree
5. Strongly agree

☐ I am interested in becoming a mentor in PAM for others in my community

☐ I have the knowledge and skills to be a mentor

☐ I have the tools and resources to be a mentor

☐ Colleagues in my community can benefit from learning and implementing PAM techniques

☐ My community can benefit from implementing PAM techniques to address local conservation issues

☐ There are organizations around me that would value this work and my expertise in this topic

Q34 How would you rate your overall experience at SIMBA?

☐ Very poor

☐ Poor

☐ Average

☐ Good

☐ Excellent

Q33 These next questions relate to SIMBA. How much did each of the following increase after attending SIMBA?

1. Not at all
2. A little
3. Moderately
4. Substantially
5. Very much

☐ Your connection to the bioacoustics community in Indonesia and Malaysia
☐ Your knowledge about the applications of PAM
☐ The likelihood of using PAM in your future work
☐ The likelihood of collaborating with people that you met at SIMBA

Q35 Do you have any suggestions for how we could improve future SIMBA events?

Q25 What were the parts of SIMBA that you found the most valuable?

3. BEAT team outputs survey (Cohort 1)

Thanks for answering the previous survey, here's a follow-up questions that we need

* Indicates required question

1. How many bioacoustics projects have you been involved with since the start of BEAT? Please briefly describe these projects below (i.e. monitoring lars gibbon population and distribution in Northern Sumatra):
Berapa banyak proyek bioakustik yang telah Anda ikuti sejak dimulainya BEAT? Mohon deskripsikan secara singkat proyek-proyek tersebut di bawah ini (misalnya, pemantauan populasi dan distribusi owa lar di Sumatra Utara):

2. What are the research output/s had been produced since BEAT? *
Apa hasil-hasil penelitian yang telah dihasilkan sejak dimulainya BEAT?
Check all that apply.

☐ Presentation; Presentasi

☐ Paper publication; Publikasi makalah

☐ Training/Workshop; Pelatihan/Workshop

☐ Community Outreach; Program Pengabdian Masyarakat

☐ Others; Lain-lain

3. Presentations; Presentasi *
How many presentation were done?

Berapa banyak presentasi yang telah dilakukan?
Mark only one oval. (0, 1, 2, 3, 4, 5 or more)

4. Could you specify the number of conferences or events, SIMBA included, where you have presented your research in bioacoustics?
Dapatkah Anda menyebutkan jumlah konferensi atau acara, termasuk SIMBA, dimana Anda telah mempresentasikan penelitian Anda dalam bidang bioakustik?

5. Paper publications; Publikasi makalah *
How many paper publication were done and/or In progress?
Berapa banyak publikasi makalah yang telah dilakukan dan/atau sedang dalam proses?
Mark only one oval. (0, 1, 2, 3, 4, 5 or more)

6. Could you specify the title/s and the status of the publication?
Dapatkah Anda menyebutkan judul dan status publikasi tersebut?

7. Training/Workshop; Pelatihan/Workshop*
How many training/workshop were done?
Berapa banyak pelatihan/workshop yang telah dilakukan?
Mark only one oval. (0, 1, 2, 3, 4, 5 or more)

8. How many training activities related to bioacoustics have you organized and/or instructed? Please provide a brief description of these training activities including the number of participants (i.e. Bioacoustics Webinar for 30 UGM undergraduate students in July, 2023).
Berapa banyak kegiatan pelatihan terkait bioakustik yang telah Anda organisasikandan/atau ajarkan? Mohon berikan deskripsi singkat mengenai kegiatan pelatihan ini,termasuk jumlah peserta (misalnya, Webinar Bioakustik untuk 30 Mahasiswa S1 UGM pada Juli 2023).

9. How many individuals participated in your training activities over the past year? Please specify the total number below.
Berapa banyak individu yang berpartisipasi dalam kegiatan pelatihan Anda selama tahun lalu? Mohon sebutkan total jumlah di bawah ini.

10. How many students or colleagues have you mentored in the field of bioacoustics since the start of BEAT (not including your BEAT team members)? Please specify the number below.
Berapa banyak siswa atau rekan yang telah Anda bimbing di bidang bioakustiksejak dimulainya BEAT (tidak termasuk anggota tim BEAT Anda)? Mohon sebutkanjumlah di bawah ini.

11. Community Outreach; Pengabdian Masyarakat *
How many outreach were done?
Berapa banyak program pengabdian masyarakat yang telah dilakukan?
Mark only one oval. (0, 1, 2, 3, 4, 5 or more)

12. Please specify the number of outreach, what it is about, number of participant, and general background of the participant (example: primary school students).
Silakan sebutkan jumlah program pengabdian masyarakat, apa yang dibahas, jumlah peserta, dan latar belakang umum peserta (contoh: siswa sekolah dasar).

13. Others; Lain-lain *
If yes, please specify the additional outputs.
Jika ya, mohon sebutkan hasil tambahan yang dihasilkan.

4. Interview guide

Review Consent and Privacy with Respondent

Advise the respondent that we will plan for 15-30 min conversation.
Ask if they have reviewed the consent form.
Ask if they would like you to read the consent form to them.
Ask if they would be okay with you recording the interview.
Ask if they have any questions about the study goals or methods.
Note: We will record the video (or audio only is fine) and use Zoom function to transcribe the interview. The video will be viewed only by the interviewer (Ayu or Jasmine) to confirm that the transcript is complete and correct. Once the transcript is confirmed, the video will be deleted from the owner's device. No copies will be retained. Transcripts will be removed of any identifiable information (name, team name, etc.) and will be labeled with only the following (this information may be collected during the interview or in WhatsApp after the interview):

▢ Country where work is conducted (Indonesia or Malaysia)

▢ Gender of respondent

▢ Highest education level completed

▢ Sector of work while participating in BEAT (e.g., academic, government, NGO, private, etc.)

▢ Number of years working in this sector and career/position level during BEAT (e.g., technician, supervisor, manager, director, etc.)

Transcripts will be reviewed by Jasmine, Ayu, and Wendy for the coding and analysis. The aggregated data summarizing these reflections will be included in a journal article about the BEAT program. We will share a copy of the published article with all participants in the BEAT program.

Ask if they understand there is no incentive or penalty for participation or non-participation. Remind them they can skip any questions or stop the interview at any time.

Semi-Structured Interview Questions (interviewer may expand as appropriate)

▢ What most motivated you to submit a proposal to BEAT?

▢ What were you hoping to get from BEAT and was this realized?

▢ What challenges did you experience during the program?

- ▢ during training sessions
- ▢ during fieldwork
- ▢ during analysis or writing
- ▢ anything else?

▢ Could you share the most important thing you learned, achieved, or developed during the BEAT program?

▢ Are you interested in continuing to use acoustics in your research? What would most help you succeed/excel on that path?

▢ What do you think is most needed to advance conservation bioacoustics in your region or community? Please specify the region or community your answer applies to.

▢ What do you think is the most urgently important information that bioacoustics could provide for you and your collaborators? What are the institutions, outputs, or pathways that make such information actionable for conservation decision-making?

☐ Do you have ideas for what BEAT (or any model of training/mentoring that supports conservation bioacousticians in your region) should focus on going forward? For example, a 'train the trainer' approach, providing extended support for existing teams, or perhaps something else?

☐ Do you want to be involved in planning the BEAT program going forward?

☐ Could you share from whom/where you get the information about BEAT program?

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SUPPLEMENTARY TABLES This supplementary material includes the following materials: SUPPLEMENTARY TABLE 1 Description of 17 BEAT teams who were selected for each of two cohorts, indicating team name, study area, sector, and research target, SUPPLEMENTARY TABLE 2 Summary of the number and proportion of interview respondents by cohort, gender, education level, work sector, and years of experience.

SUPPLEMENTARY TABLE 1 Description of 17 BEAT teams who were selected for each of two cohorts, indicating team name, study area, sector, and research target.

	Team Name	Country	Province or State	Sector	Research Target
Cohort 1	Halimun-Salak Gibbons	Indonesia	West Java	NGO	Javan gibbons
	Indonesian Urban Birds	Indonesia	Aceh, West Java, Central Java, Yogyakarta	University, NGO	Birds
	Merbabu Owls	Indonesia	Central Java	NGO	Javan scops owl
	Penang Hill Soundscapes	Malaysia	Penang	University	Soundscapes
	Peninsular Malaysia Frogs	Malaysia	Kedah	University	Frogs
	Rungan Biodiversity	Indonesia	Central Kalimantan	University	Primates, Birds, Reptiles
	Sikundur Mammals	Indonesia	North Sumatra	NGO	Large mammals
	Sungai Utik Hornbills	Indonesia	West Kalimantan	NGO	Horbnills
Cohort 2	Babi and Lasia Endemics	Indonesia	Aceh	NGO	Endemic birds and mammals
	Gunung Gede Toads	Indonesia	West Java	University	Bleeding toad
	Kinabalu Birds	Malaysia	Sabah	NGO	Birds
	Kuamut Conservation	Malaysia	Sabah, Central Kalimantan	Company	Rare, threatened, endemic species
	KuKar Mining	Indonesia	East Kalimantan	Government	Soundscapes
	Pematang Gadung Apes	Indonesia	West Kalimantan	NGO	Orangutans and gibbons
	Penang Bats	Malaysia	Penang	University	Bats
	Rimba Raya Gibbons	Indonesia	Central Kalimantan	Company	White-bearded gibbons
	Sangihe Dugongs	Indonesia	North Sulawesi	NGO	Dugongs

SUPPLEMENTARY TABLE 2 Summary of the number and proportion of interview respondents by cohort, gender, education level, work sector, and years of experience.

	Cohort 1		Cohort 2	
	N	%	N	%
Country				
Indonesia	5	36	6	43
Malaysia	1	7	2	14
Gender				
Man	3	21	5	36
Woman	3	21	3	21
Education				
Bachelor	3	21	4	29
Master's	2	14	1	7
Doctorate	1	7	3	21
Sector				
Non-profit	5	36	3	21
University	1	7	2	14
Private	-	-	2	14
Government	-	-	1	7
Years experience in sector				
≤ 1	2	14	1	7
2-5	1	7	3	21
6-10	2	14	3	21
> 10	1	7	1	7
Total	6	43	8	57