CEPF SMALL GRANT FINAL PROJECT COMPLETION REPORT

Organization Legal Name:	National Institute of Advanced Studies
Project Title:	Assessing biodiversity value of production landscape and non protected forests on sky islands by establishing occurrence of cryptic, threatened birds.
Date of Report:	10th June 2014
Report Author and Contact Information	Dr. V.V. Robin

CEPF Region:

Strategic Direction: CEPF Strategic Directions 2 Improve the conservation of globally threatened species through systematic conservation planning and action.

Grant Amount: $ 19,524.55

Project Dates: 1st March 2011 to 30th June 2013

Implementation Partners for this Project (please explain the level of involvement for each partner):

Dr. Anil Prabhakar, Indian Institute of Technology, Chennai
Co-investigator of the project and involved in all aspects of planning and implementing the project

Dr. Anindya Sinha, National Institute Advanced Studies, Bangalore
Co-investigator involved in an advisory role on the overall implementation of the project

Conservation Impacts

Please explain/describe how your project has contributed to the implementation of the CEPF ecosystem profile.

This project contributed to the CEPF Strategic Direction 1 to monitor conservation status of globally threatened species and specifically contributed to CEPF Investment Priority 1.1 to support conservation outcomes at areas outside protected areas.

This project collected data from four CEPF Site Outcomes and two CEPF Wholly Irreplaceable Sites in the Western Ghats. Preliminary data was collected from outside CEPF Site Outcomes # 63, Kotagiri and from a CEPF critical link #13, that form privately owned production landscape. A larger pilot data was collected from CEPF Site Outcome #6 Aralam & #21 Bramhagiri, from outside Site Outcome #79 Mukurthy, from outside newly declared protected areas Kodaikanal Wildlife Sanctuary and CEPF Site Outcome #95 Peppara.

Location	CEPF priority	Data description
Kotagiri	Site outcome #63, Critical link #13	Pilot automated data recorded, data analysed manually
Brahmagiri hills	Site Outcome #6	2012 bird breeding season (Jan to May) data recorded every day from 6am – 9am & 3pm – 6pm*
Nilgiri hills	Site Outcome #79	2012 bird breeding season (Jan to May) data recorded every day from 6am – 9am & 3pm – 6pm*

Agasthyamalai Hills	CEPF Site Outcome #95	2012 bird breeding season (Jan to May) data recorded every day from 6am – 9am & 3pm – 6pm*
Palni Hills	NA	2012 bird breeding season (Jan to May) data recorded every day from 6am – 9am & 3pm – 6pm*

* few days missing data due to logistical constraints: hardware or battery drained

Please summarize the overall results/impact of your project against the expected results detailed in the approved proposal.

We proposed to develop an automated song/call monitoring system that could be implemented in production landscapes and outside protected areas to estimate the biodiversity value of such landscapes. Towards achieving this goal, we planned to develop hardware to record songs/calls and the software to automatically identify the species. We were able to develop a software (algorithm) that could identify seven common bird species in this habitat and were able to use existing (purchased from third party) hardware to record preliminary data from both production landscape and from outside and within protected areas on different mountain-tops (sky islands). A test website www.bioacoustics.in is being set up where users could upload their own recordings of songs to use the developed algorithm to identify the presence of the seven species we worked on. For two threatened species, the Shortwings *Brachypteryx major* and *B . albiventris (also known as* Blue Robins Genus *Myiomela)*, we found populations on different mountains and deforested landscapes to have different bird songs indicating cultural divergence possibly due to habitat patchiness.

Attached Appendix of Results/Impacts of the project: Output_NIAS_IIT_birdsong.pdf

Please provide the following information where relevant:

Hectares Protected: Nil

Species Conserved: Nil

Corridors Created: Nil

Describe the success or challenges of the project toward achieving its short-term and long-term impact objectives.

Short-term successes

- Select common species can now be identified from songs by means of an **automated algorithm** that this project developed. The successful development of this algorithm has been a first such effort from this biodiversity hot-spot.
- The project has developed a **system** that is **fully functional**: from collection of data to identification of species and dissemination of information (through a website www.bioacoustics.in). Large-scale pilot data has been collected to demonstrate the functioning of this project.
- The project has contributed to **capacity building** by training **six students** at the graduate and undergraduate levels at both engineering and biological components. Two students (one from engineering and one from biology) won best poster and talk awards at a national conference (YETI 2011) for their research from this project.

Long term successes

- This project has highlighted the benefits of a truly multidisciplinary collaboration- between conservation biologists and engineers. Recognition of these benefits has laid the

foundations to a longer-term collaboration for further research and we are in the process of applying for a larger grant to DBT.

Challenges

- One of the major challenges we faced was the limited funding available to us. Mid-way through the project, we realized that the short-term engagements (six months) of students, especially engineers, did not contribute significantly to the project. We realized the requirement of a full-term employment of an engineer that unfortunately requires higher pay scale than available with us. Future fund raising will include such positions for better implementation of the project.
- Coordination between biologists and engineers was another major challenge in this project. Since most personnel on the project were student trainees, coincidentally the terms of the biologists and the engineers did not overlap, and also did not typically match with the mating season of the birds when a lot of data collection was done. This resulted in a serious hindrance to productivity as the engineering students did not often understand the biology behind bird songs and the biology students did not understand how the algorithms were developed. We also did not have a good mechanism in place for handing over the project to new students coming into the team within each of these teams. This often created redundancies and repetitions. We propose future studies, with longer term objectives and the ability to define student thesis around the study, to achieve better documentation, and coordination within the team.

Were there any unexpected impacts (positive or negative)?

- **Synergy with other institutions**: Even the limited success of this project raised sufficient enthusiasm among researchers in other institutions to consider developing this project into a larger project. Variety of researchers, from NGOs and academic institutions (Indian and international) have now come together to form a larger collaboration to study not just bird song, but also other acoustic elements in a larger landscape.

Name	**Institution**	**Motivation/Interest**
Tarsh Thekaekara	Shola Trust	Interested in using automated devices, especially through local schools to monitor bio-diversity at a large scale.
Samira Agnihotri	Centre for Ecological Science, Indian Institute of Science, Bangalore	Overall concept; has also worked with engineers on automated algorithms to identify species
Venkatesh Gopal,	Asst. Professor, Department of Physics, Elmhurst College, IL, USA	Hardware; is interested in producing automated units that can also record images with camera-traps
Satish Babu	Director, International Centre for Free and Open Source Software	Hardware; has produced automated weather data collection units in India. Interested in biological applications
Thippur Srinivas	Professor, ECE Department, Indian Institute of Science, Bangalore	Software/ speech and audio models especially multi-microphone models. Interested in other biological systems

Lessons Learned

Describe any lessons learned during the design and implementation of the project, as well as any related to organizational development and capacity building. Consider lessons that would inform projects designed or implemented by your organization or others, as well as lessons that might be considered by the global conservation community.

- **Staying open to collaborations**: Since the project had wide applications, many other researchers were interested in joining the initiative to develop and implement the project. Staying open and welcoming to new collaborations has seen the project grow both conceptually and also in its potential reach with implementation. Follow further developments at http://skyisland.in/Song.html
- **Coordination**: One of the biggest lessons we have learnt is that in a multi-disciplinary project, it is important to have good coordination between different groups and it is even better if different groups are located in the same physical space to increase productivity.
- **Public involvement**: The scale of the project was so large that generating training data (to identify species) for many species was challenging even with dedicated team members on the job. We now believe that this is achievable through public participation (citizen science models) and crowd-sourcing the training data.
- **Long-term funding**: Although this project provided a proof-of-concept, actual applications would require further studies, with longer term objectives, steady funding and longer term student involvement (perhaps as thesis around the study), to achieve better documentation, and coordination within the team

Project Design Process: (aspects of the project design that contributed to its success/shortcomings)

- **Collaboration between biologists and engineers**: The strength of the project was the unique collaboration between conservation biologists and engineers. Having people with specific skills permitted the development of a solution to the scientific question we proposed.
- **Systematic sampling for data**: Our biological data collection (song recordings) had a robust study design as we sampled for geographic variation across the different mountains of Western Ghats. This study design let us use even the preliminary data to investigate geographic variation in bird song across a few threatened, endemic species (also CEPF Species Outcomes).
- **Clear objectives**: This study had very specific goals and the limits to what the project set out to achieve was clearly articulated. The biological question of species identification was limited to a landscape and thus to a specific set of birds. This let us achieve reasonable success with the project. This also helped both the biological data collection team (in collecting training data) and the engineering team (to develop the species identification algorithm) stay focused on the specific question.
- **Coordination challenge**: The biggest challenge this project faced was keeping coordination both across the two teams (biological & engineering) that were also geographically separated (Bangalore and Chennai) and within teams between multiple short-term student trainees. This has now led us to conclude that any future collaborative project should have a central full-time person who can coordinate activities of different teams that are ideally located in the same physical location.
- **Sustainability planning**: In retrospect, the project aimed to do too much with a limited budget. The additional support sought from Rainforest Alliance (even in-kind support) towards recording equipment was not successful. We also applied for funding from an engineering perspective (Anil) but that was also unsuccessful. Being an inter-disciplinary project, there was considerable confusion where such a project could be sent for funding within India.

- **Funding:** Additional funding is being pursued to take the project forward to encompass more species across India (from the present Western Ghats focus)

Project Implementation: (aspects of the project execution that contributed to its success/shortcomings)

- **Wide support from various institutions**: The project enjoyed the support of several institutions, companies and individuals based at different locations in the Western Ghats. Our efforts to explain the project to different individuals and the potential to conduct automated biodiversity inventory increased interest in the project. Many plantation owners encouraged us to implement pilot studies in remnant forests in their holdings. Such outreach helped us collect data from a variety of locations.
  These include:
  - Keystone Foundation, Kotagiri
  - Vattakanal Conservation Trust, Kodaikanal
  - Nature Conservation Foundation, Mysore
  - Foundation for Ecological Research, Advocacy and Learning (FERAL)
  - Iyerthottam plantations Kotagiri
  - Havukal plantations, Kotagiri

- **Student trainees**: Collection of preliminary biological data from different mountain-tops was extremely strenuous and time and effort intensive. Having young motivated student trainees helped the project since their sheer enthusiasm allowed them to climb up and down steep mountains to monitor recorders and collect data that was critical for this project.

Other lessons learned relevant to conservation community:

- Preliminary song data from two CEPF species outcomes reveals that bird songs are divergent across anthropogenically fragmented landscape. This shows that the effect of fragmentation can also lead to cultural divergence apart from other genetic or population demographic effects.
- Involving a larger community of researchers working locally at different locations can aid projects and increase enthusiasm and dynamism in such projects.

ADDITIONAL FUNDING

Provide details of any additional donors who supported this project and any funding secured for the project as a result of the CEPF grant or success of the project.

Donor	Type of Funding*	Amount	Notes
IIT	A	$ 5000	Towards manpower
NCBS	B	$ 3000	Towards field expenses

Additional funding should be reported using the following categories:

A *Project co-financing (Other donors contribute to the direct costs of this CEPF project)*

B *Grantee and Partner leveraging (Other donors contribute to your organization or a partner organization as a direct result of successes with this CEPF project.)*

C *Regional/Portfolio leveraging (Other donors make large investments in a region because of CEPF investment or successes related to this project.)*

Sustainability/Replicability

Summarize the success or challenge in achieving planned sustainability or replicability of project components or results.

- **Codes open source**: One of the major highlights of this project is that all relevant codes and techniques will be made accessible to the public through the project website (www.bioacoustics.in). We hope that this will aid transparency and with increased participation from others, it will improve our own efforts at solving this research problem.
- **Data available to public**: The data generated from this study will be made available to any registered member of our project website. We will also share the data with other open source data sharing portals such as Western Ghats Biodiversity Portal.

Summarize any unplanned sustainability or replicability achieved.

- Popular and academic talks about the project generated enthusiasm among other researchers leading to larger collaborations. Another CEPF grantee, Tarsh Thekekara from The Shola Trust along with Dr. Venkatesh Gopal, Asst. Professor, Department of Physics, Elmhurst College, IL, USA, and Samira Agnihotri, Centre for Ecological Science, Indian Institute of Science have joined to form a larger collaboration to develop algorithms to identify bird species in different habitats. This larger project resulting from the CEPF funded initial project will generate its own funding. Developments on this project can be followed at http://skyisland.in/Song.html and http://birdsongs.in/ or http://www.bioacoustics.in/

Safeguard Policy Assessment

Provide a summary of the implementation of any required action toward the environmental and social safeguard policies within the project.

Not applicable

Performance Tracking Report Addendum

CEPF Global Targets

(Enter Grant Term)

Provide a numerical amount and brief description of the results achieved by your grant.
Please respond to only those questions that are relevant to your project.

Project Results	Is this question relevant?	If yes, provide your numerical response for results achieved during the annual period.	Provide your numerical response for project from inception of CEPF support to date.	Describe the principal results achieved from 1st March 2011 to 30th June 2013. (Attach annexes if necessary)
1. Did your project strengthen management of a protected area guided by a sustainable management plan? Please indicate number of hectares improved.	No			Please also include name of the protected area(s). If more than one, please include the number of hectares strengthened for each one.
2. How many hectares of new and/or expanded protected areas did your project help establish through a legal declaration or community agreement?	No			Please also include name of the protected area. If more than one, please include the number of hectares strengthened for each one.
3. Did your project strengthen biodiversity conservation and/or natural resources management inside a key biodiversity area identified in the CEPF ecosystem profile? If so, please indicate how many hectares.	No			
4. Did your project effectively introduce or strengthen biodiversity conservation in management practices outside protected areas? If so, please indicate how many hectares.	No			
5. If your project promotes the sustainable use of natural resources, how many local communities accrued tangible socioeconomic benefits? Please complete Table 1below.	No			

If you answered yes to question 5, please complete the following table.

Table 1. Socioeconomic Benefits to Target Communities

Please complete this table if your project provided concrete socioeconomic benefits to local communities. List the name of each community in column one. In the subsequent columns under Community Characteristics and Nature of Socioeconomic Benefit, place an X in all relevant boxes. In the bottom row, provide the totals of the Xs for each column.

Name of Community	Community Characteristics								Nature of Socioeconomic Benefit												
									Increased Income due to:												
	Small landowners	Subsistence economy	Indigenous/ ethnic peoples	Pastoralists/nomadic peoples	Recent migrants	Urban communities	Communities falling below the poverty rate	Other	Adoption of sustainable natural resources management practices	Ecotourism revenues	Park management activities	Payment for environmental services	Increased food security due to the adoption of sustainable fishing, hunting, or agricultural practices	More secure access to water resources	Improved tenure in land or other natural resource due to titling, reduction of colonization, etc.	Reduced risk of natural disasters (fires, landslides, flooding, etc)	More secure sources of energy	Increased access to public services, such as education, health, or credit	Improved use of traditional knowledge for environmental management	More participatory decision-making due to strengthened civil society and governance.	Other
Total																					

If you marked "Other", please provide detail on the nature of the Community Characteristic and Socioeconomic Benefit:

Additional Comments/Recommendations

- Continuation grants from CEPF-ATREE required: This project suffered from not having continued funding. During the period of this CEPF-ATREE Grant, there was no option to obtain additional funding from CEPF. At the time of inception of this project, there were very few such efforts globally and this project was at the forefront of such research globally. However, with the slow pace of this project, several other international efforts have now solved the academic problem of species identification (for their data sets) in different parts of the world (Brazil, North America and Europe). As explained previously, the project would have gained tremendously by longer-term employment of engineers (that was not possible with the current funding levels) and this was not possible in the current format of CEPF. It would be beneficial to have possibilities of extended funding in cases where the additional funding would make an enormous difference to the project.

- More positive engagement from CEPF-ATREE required: At the inception of the project, there were a lot of delays in contracting and subsequently release of funds. We were hearing comments like “IIT’s have a lot of money, why should we give it any money?” Consequently, the entire budget was given to NIAS and IIT Madras accepted no funding. This seriously setback the hardware development that was envisaged in this project. In fact, no hardware development was undertaken and we instead used commercially available hardware. There was a lack of understanding that faculty at IIT-Madras (like any other US or EU university) are also supposed to raise funds for their research through agencies, such as CEPF. We understand that CEPF-ATREE interacts more with NGOs and is not used to dealing with government run research institutions. However, by killing the funding towards IIT-Madras, the interdisciplinary nature of the project was undermined. A more positive and open attitude may welcome different / non-conventional parties to conservation and may prove to be more productive with respect to conservation action.

Information Sharing and CEPF Policy

CEPF is committed to transparent operations and to helping civil society groups share experiences, lessons learned, and results. Final project completion reports are made available on our Web site, www.cepf.net, and publicized in our newsletter and other communications.

Please include your full contact details below:

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Organization name: National Center for Biological Science
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Appendices:

1) Student poster on project
2) Map of the locations of sensors deployed in Western Ghats
3) Results/Impacts of the project
4) Final Technical Report

Implementation of modified SEAV for Identification of Bird Species through Calls

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Introduction

An assessment of biodiversity is often difficult with traditional methods since they are either labour or time intensive. We propose to build an automated audio monitoring system for identification of bird species based on songs and calls recorded from the wild. Such methods can then be used to estimate diversity of birds in an area. In the first stage of this project, we proposed to build an algorithm that can effectively separate and identify the songs of two bird species Magpie Robin Copsychus saularis and White-bellied Shortwing Brachypteryx albiventris.

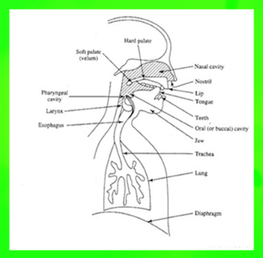
Applications of Bird Call Identification

* Meaningful research on taxonomy
* Monitoring of bird migration in ornithology
* Significance in biological studies
* Bird watching

Call Production Mechanisms

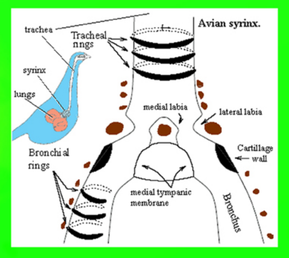
Human speech production mechanism

* Multi Resonator mechanism
* Sound production depends upon the positions of various articulators
* Vibrations of the membranes of human vocal chords produces vowel sounds



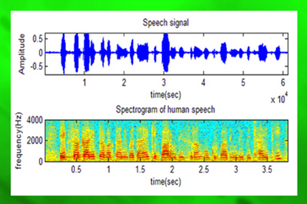
Bird call production mechanism

* Single Resonator mechanism
* Sound production results due to sound waves originating from channels of air flow within the syrinx
* Vibrations of the membranes within a birds syrinx produces bird calls

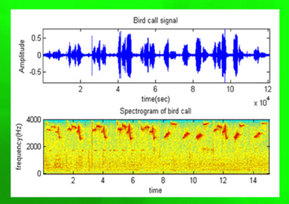


Spectrogram comparison of human and bird vocalizations

The spectral properties of bird vocalizations are quite different from that of human speech.



Human Vocalizations
* The high energy regions are often distributed over a larger spectral range, due to fricatives and the formants in vowels.



Bird vocalizations
* Generally very tonal, consisting of either a single frequency at a given point in time, or of a frequency and a few harmonics.
* Most of the energy is located in a narrow region of frequency

Modified Spectral Ensemble Average Voice-prints (SEAV)

Need of a new algorithm?

Human speech is much more complex compare to bird calls. So instead of using complex algorithms which were used for speech signals we can develop a new algorithm especially for bird call analysis.

The proposed algorithm should have following merits in it:

* Use lesser computation
* Easy to implement on a low end processor
* Cheap
* Accurate

SEAV Algorithm

The algorithm for computing the SEAV is as follows:

* En frame the bird call signal with a frame size of 20ms and frame rate of 10ms.

* Compute the N point FFT of each frame of the windowed bird call signal x(m) as

$$X(k) = \sum_{(m=0)}^{(N-1)} [x(m)e^{(-j2\pi m\, k/N)}]$$

where k = 0,1,……, (N-1)

* Compute the ensemble average of the FFT spectrum across all the frames. If there are J frames in the bird call signal then the spectral ensemble average (SEAV) is computed as

$$X_{seav}(0)=X_1(0)+X_2(0)+X_3(0)+ \ldots\ldots\ldots\ldots +X_J(0)$$
$$X_{seav}(1)=X_1(1)+X_2(1)+X_3(1)+ \ldots\ldots\ldots\ldots +X_J(1)$$
$$X_{seav}(2)=X_1(2)+X_2(2)+X_3(2)+ \ldots\ldots\ldots\ldots +X_J(2)$$
$$\ldots\ldots\ldots = \ldots\ldots\ldots + \ldots\ldots\ldots + \ldots\ldots\ldots + \ldots\ldots\ldots + \ldots\ldots\ldots$$
$$X_{seav}(N/2-1)=X_1(N/2-1)+X_2(N/2-1)+X_3(N/2-1)+ \ldots\ldots\ldots +X_J(N/2-1)$$

* The vector $\{X_{seav}(0),X_{seav}(1),X_{seav}(2),\ldots\ldots\ldots,X_{seav}(N/2-1)\}$ of length N/2 is the SEAV corresponding to each bird.

Modifications over the past SEAV approach

Following modifications were made in the above algorithm for its implementation on a low end processor as well as for processing the field recordings of bird call.

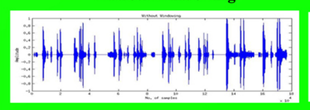
(1) Frame size correction

(2) Dropping out zero crossing rate criterion

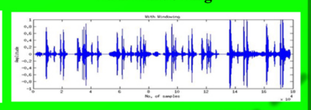
(3) Fixing of energy threshold

(4) Windowing concept

Without Windowing



With Windowing

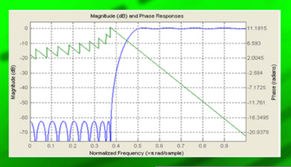


(5) Use of front end filter for cleaning the data

Filter Parameters

- Order of the filter = 34
- Stopband Frequency = 1500
- Passband Frequency = 2000
- Stopband Attenuation (dB) = 60
- Passband Ripple (dB) = 1
- Sampling Frequency = 8000

Filter Response



Algorithm Implementation

Database Preparation

Earlier, cage recordings of birds were used for the implementation of SEAV. Those samples differed greatly from the real-time recordings because they were free from background noises. The data required was taken from the recordings done in the forests of different parts of Western Ghats, India.

* Recording and Sampling of calls (Sampling rate 8 kHz)
* Removal of backgroun noise by Front-end filter
* The bird call is first windowed into a number of frames with a frame rate of 32ms and an overlap of 16ms. Frame size of 32ms with 8 kHz sampling frequency

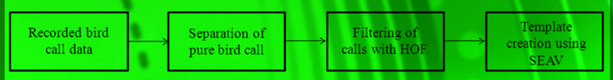
S. No.	Species	Total # recordings	Rejected (bad) recordings	# recordings used for template creation	# recordings used for testing
1.	Magpie Robin	16	3	6	13
2.	White Bellied Short-Wing	20	5	7	15

Implementation of modified SEAV

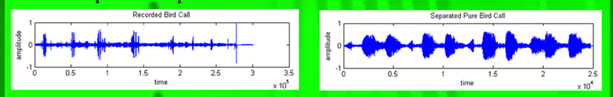
Modified SEAV for bird call identification was implemented in two parts:

A. Source Template Generation

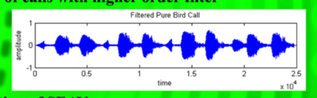
As a first part of our recognition process, we first analyzed the recorded data and with the help of this we created some source templates for each species. Source template is basically the signature of a birds call. Source template is stored in system which later will be used for classification of the test template.



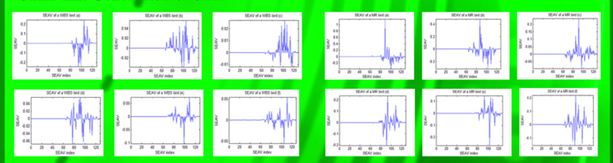
STEP I: Separation of pure bird calls



STEP II: Filtering of calls with higher order filter



STEP III: Generation of SEAV



From above SEAV plots analysis, we can see that calls of different birds include different spectral content & SEAV is an efficient tool for bird call identification.

B. Test template creation and classification

The second part of the implementation involves test template creation. After the source templates were created and stored in the system, they are used for the identification of birds in real time.

Test templates were created using the following steps:

STEP I: Filtering of Data
STEP II: Energy threshold for identification of calls
STEP III: Windowing of calls
STEP IV: Test template creation using SEAV

Results and Conclusion

We created 6 templates for Magpie Robin and 7 templates for white bellied short wings.

Accuracy of SEAV is defined as:

$$\%\ \text{Accuracy} = \frac{\text{(No. of positive calls identified)}}{\text{(Total no. of calls identified)}} \times 100$$

By the formula above, we have calculated the accuracy given by our algorithm in the detection of both the test species of birds, and the corresponding results are shown in the bar graph below.

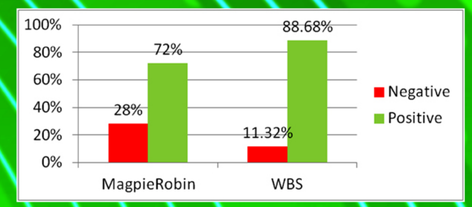


Figure: SEAV results for various species.

Modified SEAV worked very significantly on real time field recorded data. It showed:
* 72% positive result for Magpie Robin & 88.68% for WBS
* Overall efficiency of the system around 80%

This is an encouraging result showing potential of modified SEAV over the conventional speech recognition methods. Modified SEAV implementation on real time field recorded data was found to be pretty accurate.

Future Scope

1. Extension to more number of species
2. Hardware Implementation
3. Development of iOS/Android app
4. Development of Bird Call Identifier software

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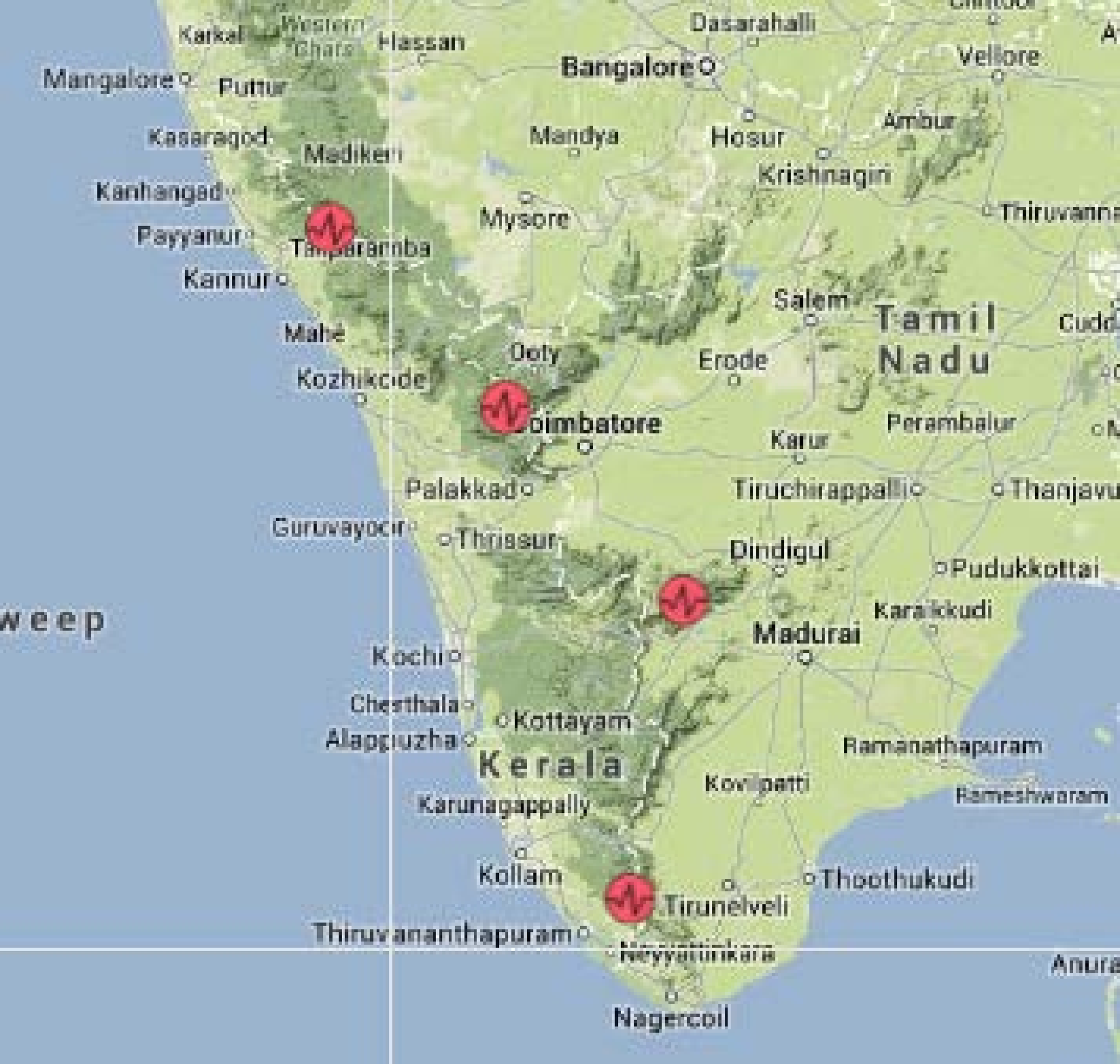
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Karaikkudi
Madurai
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Alappuzha
Ramanathapuram
Kerala
Kovilpatti
Rameshwaram
Karunagappally
Kollam
Thoothukudi
Tirunelveli
Thiruvananthapuram
Nagercoil

RESULTS/IMPACT OF NIAS-IIT BIRD SONG PROJECT AGAINST THE EXPECTED RESULTS/OUTCOMES

Sl. No.	Proposed output	Status
a.	*Private forest owners will be sensitized to presence of threatened, endemic birds in their forests and a checklist will be provided to them*	Private tea estate owners were visited to discuss the value of the proposed project. We received considerable support and enthusiasm from the owners visited and they permitted and facilitated us to conduct field visits and conduct recordings using purchased automated recorders. These recordings have bird song data from the private forests. Since our algorithms could detect only seven bird species, we could not provide a list of the species at these forests. However, this will be possible once the ongoing software development (with new funding) is complete. We had attempted to manually identify birds from these recordings, but we had to give up this effort since it took over four months to get through just parts of recordings from one estate.
b.	*Presence of endemic, threatened bird species outside protected areas from CEPF critical corridor outcome region will be known*	Towards this outcome data has been collected, but with only partial success of our species identification algorithms, a final list of birds has not been produced. However, since the data exists and algorithm development is ongoing (with funding from

		other agencies described in the main body of the report), we will be able to provide this information at a later date.
c.	*A list of threatened, endemic birds and the location where they were detected will be provided to organisations like Nature Conservation Foundation and Rainforest Alliance so that they are aware of species that are likely to be detected from similar regions during their audits or certification.*	Towards this outcome data has been collected, but with only partial success of our species identification algorithms, a final list of birds has not been produced. However, since the data exists and algorithm development is ongoing (with funding from other agencies described in the main body of the report), we will be able to provide this information at a later date. Some efforts to involve Rainforest Alliance in this project were not successful and CEPF-ATREE were kept informed of these developments.
d.	*We will facilitate Nature Conservation Foundation and Rainforest Alliance to carry out audits at the study locations using this technology should all parties be willing to such an endeavour*	Some efforts to involve Rainforest Alliance in this project were not successful and CEPF-ATREE were kept informed of these developments. With the present partial success of the algorithm, we were unable to develop a meaningful relationship with NCF and Rainforest Alliance other than keeping them updated of the project's progress through personal communication as well as talks at NCF annual meetings (2013 and 2012).
e.	*List of threatened,*	Towards this outcome data

	endemic mammals and tree frogs will also be generated	has been collected, but with only partial success of our species identification algorithms, a final list of species has not been produced. However, since the data exists and algorithm development is ongoing (with funding from other agencies described in the main body of the report), we will be able to provide this information at a later date. However, both tree frog and mammal researchers were consulted during trial deployment of the recorders. Our current collaboration as a continuation of the project funded by CEPF-ATREE includes researchers who are planning to use this system to monitor various other taxa including monitoring of human-elephant conflict.
f.	*Stand-alone recording units will be developed and produced (not for profit) that can be deployed in any area to detect and record endemic birds with a potential for the area of coverage to be scaled up immensely.*	This aspect of the project faced two major challenges i) lack of manpower interested in working at the interface of engineering and biology and ii) lack of funding to one of our collaborators (comment in the feedback section of the main report). Despite these challenges, we were able to develop a preliminary model, but could not be deployed on field due to its bulky nature (see image of a

		similar prototype developed for CO2 monitoring). We are currently pursuing a development of an advanced model that can be deployed on field with the additional funding (from other agencies) that we are now seeking.
g.	*Existing technological know-how will be used as a demonstration to further ecological understanding for conservation.*	We were able to achieve considerable success with this aspect of the project. Talks were given at various locations (some through CEPF-ATREE organized meetings) and some student conferences. Based on the reviewers at these conferences, best poster and talk awards were received by the participating students. Several local NGOs have agreed to help coordinate field deployment should be able to provide such units to them. With continued funding (from other agencies) we will continue to communicate the role of this project in conservation.
h.	*Data from the recording units will be made available as part of an open access biodiversity database for anyone to download and analyse to examine other patterns of interest.*	We have been able to partially complete this output. A preliminary website has been developed and is at www.birdsongs.in , a server for the project has been purchased (with other funding) and is at the NCBS server room. After further development of the species recognition algorithm, the

		website will be hosted through NCBS server at www.bioacoustics.in. We are also discussing modalities of making our data also available through www.indiabiodiversity.org. At present the data has not been shared due to the large file sizes. For example data from just one season's recording is about one TB while more meaningful splits of the dataset, without background noise but with animal sounds, with smaller file sizes generated through an algorithm, will considerably reduce the logistical constraints. Such an algorithm is being developed (with other funding) and the data will be made available after this is completed.