<u>Barun Biomeridian Research Project</u>

(Measuring Life and Informing Sustainable Community Adaptation to a Changing World)

Summary Report of Project's Achievements
(April 2019 - March 2021)

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Introduction

Scientific literature-based assessment of atmospheric and surface climate observations reported that the global mean surface temperature has increased since the late 19th century, and the decade of the 21st century has been the warmest (Hartmann et. al., 2013). The temperature increase in the same period is not the same in all regions, and the trend of warming differs at different altitudes in the same region too. Studies conducted by International Centre for Integrated Mountain Development (ICIMOD) revealed that there is an increased magnitude of warming (0.01 to 0.060C/yr.) with elevation in the eastern Himalayas.

Natural vegetation has already been exhibiting a response to global warming through structural changes in forests and vegetation. These changes are subject to lead to create negative impacts on agriculture and food security, water resources, forests and biodiversity, health, tourism, and infrastructures, and ultimately reduce adaptive capacity and increase the vulnerability of communities and ecosystems.

Climate change is a global phenomenon but wherever people live at the local level, they have to face the negative impact of climate change while they act as the users and guardians of nature and its resources. Around the world, the balance of life is changing rapidly due to climate change. To facilitate informed adaptation to climate and anthropogenic change, local communities need to be informed about what is happening in their specific areas and then engage in learning how they can begin a process of steady adaptation where the result is for the quality of their lives to improve.

The mountain slope encapsulates the natural diversity ranging from the Equator to the poles, mirroring latitudinal shifts in vegetative and animal complexes within short vertical distances. Mountain communities are, therefore, at the center of many of these changes. Future Generations University (FGU), a West Virginia, USA-based academic institution wishes to engage itself to develop resilience and adaptive capacity of local communities to cope with the impact of climate change through integrating scientific information and local engagement. As such, to establish an international network of biodiversity monitoring transects–arrays of instrumentation stations along mountain transects, partnering with local communities and collaborating with The East Foundation (TEF), a local NGO the University chose Barun Valley (one of the most pristine valleys with rich biological diversity) lying within the Makalu Barun National Park (MBNP) in Nepal. Long-term monitoring along these transects will lead to a continually growing understanding of how flora and fauna adjust to anthropogenic and climate change. On the other hand, combining data from scientific instrumentation with local knowledge informs people so they can evolve increasingly effective responses to ecosystem destabilization on a changing planet.

With the support and permission of the Department of National Parks and Wildlife Conservation (DNPWC), the Nepal Government, FGU, and TEF conducted a preliminary feasibility study in the valley in 2018. The study recommended a need of continuing the work for a long period of time. Hence, based on the feasibility study's findings and lessons learned, and fitting with the MBNP’s management plan (2017-2022), a five-year plan proposal was developed which includes both scientific work and community engagement and trainings in order to meet the following primary objectives:

a. to utilize scientific observations along transects to establish a baseline for biodiversity upon which changes due to climate change and anthropogenic effects can be monitored;

b. to examine biodiversity and changing dynamics using sound;

c. to develop deep partnerships with local communities as co-equal investigators and users of the resulting data; and

d. to provide training to encourage the development of the socio-ecological resilience and adaptive capacity of local communities in a changing environment.

The proposal was submitted to DNPWC for permission to conduct the plan for five consecutive years as Barun Biomeridian Research Project. The Government granted permission for 2 years to be effective from April 2019. As per the agreement, Project's achievement reports (April 2019 to September 2019) and (October 2019 to March 2020) have been submitted to DNPWC, and a presentation was also performed at the department's premises in November 2019. The global COVID-19 pandemic influenced also the project's second year of work. Despite this, field technical staff made a series of trips to the plots/stations to download the meteorological, bioacoustics, and camera-trapped data recorded by the devices. As per the discussion with the concerned authority of DNPWC, a summary report of the achievements made during the two years period has been prepared as follows.

Photo 1: Project's achievement presentation in DNPWC, 2019

Achievements

Scientific works

Data collection foundation

Permanent plot establishment

Barun valley covers a wide range of bioclimatic zones starting from subtropical to nival. A total of eight circular permanent plots each 20-meter diameter were established at each bioclimatic zone and ecotone up to tree line along the biomeridian that stretches up along the Barun river from Barun Dovan (ca. 1100 m) (Figure 1). Plots were not established below the Hinju site (1800m) because of lying the land under private ownership. Two reference points have been set to detect each plot: one on the biomeridian trail and another at the center of the plot. The former is denoted with a remarkable object while the latter with a tree but both are supplemented with altitude and geo-coordinates information (for detail see Project's achievement report April 2019 - September 2019).

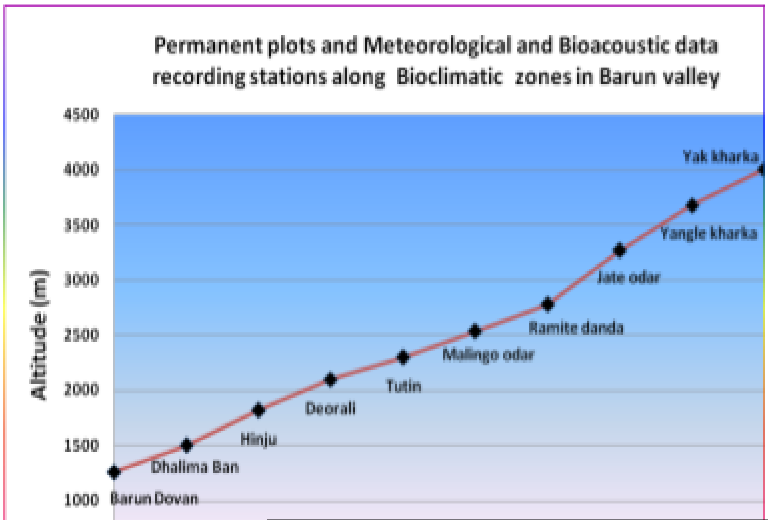

Figure 1: Data collection plots/stations

HOBO devices installation

A total of eight HOBO loggers (meteorological data recorders) were installed on the reference trees with one in each plot (Figure 1). The loggers collect temperature and relative humidity data. HOBO MX2301 model loggers were installed in five stations while HOBO Pendant loggers were in other sites. In November 2019, the MX2301 model loggers were upgraded to MX2301A, and HOBO Pendants were replaced with HOBO MX2301A (for detail see Project achievement report October 2019 to March 2020). Technical problems happened to appear in some devices now and then, have been reported which are replaced if the stock was available otherwise sent to the USA for repair. As such, some of the broken equipment has been sent to the USA.

Bioacoustics devices installation

Similar to HOBO loggers, a total of eight Bioacoustics devices (song data recorders) were installed on the reference trees with one in each plot (Figure 1). In the beginning, the devices were loaded with firmware ver. 2.0 which was updated to ver. 2.2 in May 2019. The devices were powered with internal Alkaline D-Batteries which need to be replaced with new ones every 2 to 3 month intervals. Due to the difficult terrain and adverse climatic conditions, it was difficult to replace the batteries in time. This warranted a need to replace the internal battery power system with an external one. As such, in November 2019, all the Alkaline D-Batteries driven systems were replaced with external power systems of solar panels (for detail see the Project achievement report October 2019 to March 2020).

Browning Trail Cameras installation

A total of four motion-activated browning trail cameras were installed at different elevations. Some photos are embedded with the wrong date due to a camera setup error, but all cameras were serviced and reset in November 2019. Additionally, the results of the initial camera trap analysis were used to reposition several wildlife cameras in November 2019 to locations more optimal to capture photographs of birds and mammals. As such, current sites in operation are Kali Khola (2012m), Cyamlima camp(2512m), Ramite danda (2780m), and Bagare(3020m).

Data collection and processing

Ecological data

General biophysical information in each plot has been collected. In addition, spatial and ecological (density, DBH, height, and canopy cover) data of major canopy tree species within the plot have been collected. That accounts for 42 individual trees which belong to different species, genus, and/or family (for the detailed report see Project's achievement report April 2019 to September 2019). It is scheduled to collect the ecological information at the interval of four years. General floral and faunal information along the trail was also collected.

Meteorological data

HOBO loggers have been set to record the meteorological data at an interval of 15 minutes throughout the year. As such, each logger does record about 35,000 records of data per year but due to the occurrence of technical problems in some devices now and again and different installation dates and times, the volume of recorded data has differed from station to station (Table 1). A total of 449,187 records of data have been collected from March 2018 to January 2021. As yet, the devices of Barun dovan and Deorali danda were found to have been recording without any problem/interruption.

Station	No. of Records
Barun dovan	100,504
Dhalima ban	56,363
Hinju	14,709
Deorali	100,602
Tutin	31,662
Ramite danda	65,904
Yangle kharka	47,796
Yak kharka	31,647
Total	**449,187**

Table 1:Meteorological dataset by station

Bioacoustics data

Bioacoustics devices have been programmed to record all sounds including that of birds, mammals, insects, etc around its periphery for 5 consecutive minutes at intervals of 10 minutes from one hour before sunrise to one hour after sunset. Each 5-minute recording creates a file of about 27 MB in size. As such, altogether 76,677 sound data files have been so far created which accounts for 2.173 TB (Table 2). The variation of data volume by stations is due to the different installation dates and times and to the technical problems that occurred in the devices as in HOBO loggers. To manage the large amount of data, a TensorFlow machine learning model has been coded which, using Databricks, distributes the data over dozens of virtual machines to store and process swiftly in the cloud.

Stations	No. of files	Amount of data (GB)
Barun Dovan	16,270	435.10
Dhalima Ban	6,576	295.77
Hinju	12,762	341.50
Deurali Danda	14,723	396.20
Tutin	8,999	240.70
Ramite Danda	10,563	281.76
Yangle kharka	4,700	125.90
Yak Kharka	2,084	55.90
Total	76,677	2172.83

Table 2: Bioacoustics data by stations

Processing large amounts of data is not possible without a computer for which the computer needs to be trained. Computers can learn the spectrum of frequency of sound signals (spectrogram) of any objects such as species, wind, rainfall, etc, and then quickly scan large quantities of data to identify those calls. Spectrogram which is very important for machine learning analysis differs from species to species as differing their calls and songs. As such, an analysis tool has been developed to efficiently extract information from the hours of bioacoustics data. Five bird species have been selected to test the tool. As an example, figure 2 shows a spectrogram of the White-gorgeted Flycatcher (one of the selected bird species) where the species' call and song, the "thin, high-pitched whistling songs including metallic “dik” sound - metallic scolding rattle and short, and plaintive whistle" is

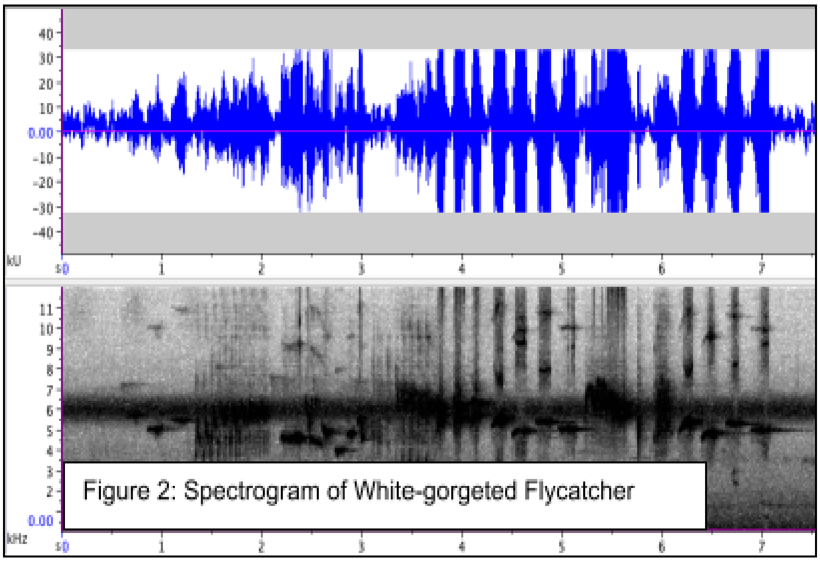

Figure 2: Spectrogram of White-gorgeted Flycatcher

represented by a spectrum of a smattering of short notes right around the 4500 Hz frequency band with alternating high-low-high-low and with the steady band of energy in the spectrogram around 6000 Hz.

Bioacoustics data contains the sound of species of various taxa. It would, therefore, serve as a primary dataset for a wider range of studies and research. Several hundred recordings of the same labeled sound/call are needed to train the computer for which participation of a larger number of personnel (natural resource managers, conservationists, academicians, researchers, interested community persons, etc.) would play significant roles even for substantial use of the primary data. As such, to facilitate the participants to listen to the sound of the species of their interest and to subsequently label them along with providing supplementary information on their certainty, type, sub-label, and notes, an online interface computer model, called Earth Hz has been created (Figure 3). The developed AI (Artificial Intelligence) model based on songs is able to scan recordings of multiple birds. Once the model is trained, the computer is able to find the calls in years of data. So far, based on 195 files of bioacoustics data recorded from 2018/03/05 to 2019/06/01, a total of 1761 spectrograms belonging to the sounds of bird, mammal, amphibian, insect, livestock, rain, wind, and river have been identified and labeled, of which 1339 labels belong to 22 species of bird. Amongst 270 spectrograms represent the call and song of Glaucidium brodiei, a rare resident bird which has been taken as an example for illustrating the machine analysis as follows.

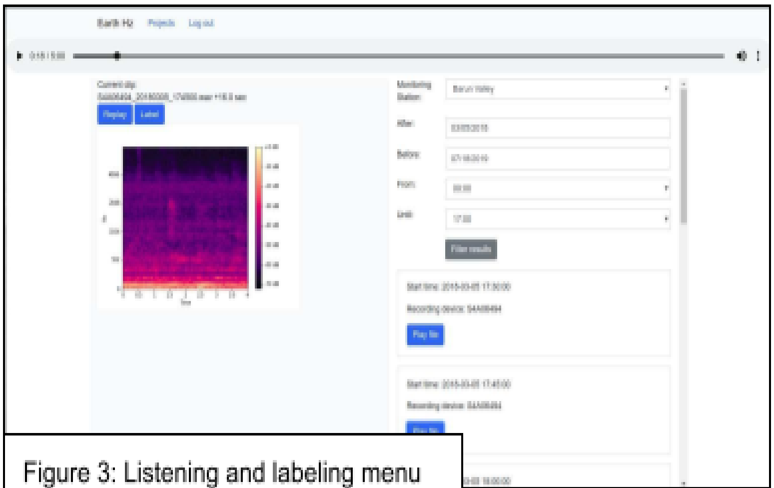

Figure 3: Listening and labeling menu

The developed AI model was designed to be applicable for all the project's sites of Future Generations University such as Makalu-Barun National Park in Nepal, Madidi National Park in Bolivia, and Chesapeake Bay Watershed in the USA. Any interested person can get into any project site of interest through www.future.edu or www.songsofadapation.org. In each site, the model prompts the participants to choose the station, date, and time of their interest and accordingly plays the audio of selected options where the sound of the species of interest is selected and labeled (Figure 3).

Figure 4: Machine learning result of *G. brodiei*

A "Visualize Results" option in the main menu is designed to analyze the recordings of the selected species based on the developed labels. Machine learning result is visualized as shown in Figure 4 where recordings of *Glaucidium brodiei*'s calls and songs were recorded from March 2018 to Sept 2019, as an example, it has been presented showing its higher recordings at Deorali danda station from November to April.

Camera trapped data

As the camera is activated by the motion of the object it is focused, a photo of even a single object is captured several times until its movement is stopped. As such, almost half photos of the total 1648 camera traps at Kali khola site were of Himalayan Serow (Table 3). Likewise, 168 and 512 photographs of Himalayan goral were captured at Ramite danda and Kali khola respectively. Despite the large amount of captured photos of faunal species, falsely triggered due to the vibration of vegetation also amounts too large. About 94% of photos captured at Yangle kharka are due to vegetation vibration. So far, a total of 5176 photos were captured of which three photos of Red Pandas were captured at Yangle kharka (Photo 2) and a photo of a Black bear at Bagare (Photo 3). Some of the faunal species and the number of their photos captured, as an example, have been presented in table 2.

Mammals		Birds	
Species	No. of Photos	Species	No. of Photos
Barking Deer	158	Blue Whistling	55
Red Panda	3	Hill Partridge	15
Himalayan Goral	681	Himalayan Monal	20
Nepal Grey Langur	2	Alpine Thrush	12
Himalayan Serow	839	Rufous-bellied	1
Himalayan Tahr	12	Small Niltava	6
Orange-bellied	36	Yellow-bellied Blue	10
Spotted Linsang	4	Black-faced Laughing thrush	4

Table 3: Number of Camera trapped photos by species

Photo 2: Red panda at Yangle kharka (36

Photo 3: Black bear at Bagare (3020m)

Community Centered Works

Barun Biomeridian Research Project Task Force Committee

A Task Force Committee for the Project has been formed under the coordination of the Chief Warden of the Makalu-Barun National Park on May 25, 2019. The committee comprises a coordinator and six members. The Chief Warden of the National Park becomes the coordinator of the committee, and the members are three (2 assistant wardens and one ranger) from the National Park, one from the Buffer Zone committee, one from The East Foundation, and one from Future Generations University.

Local Coordination Committee

A Local Coordination Committee was formed in Bhotkhola Rural Municipality-4 during the project's preliminary study period in 2018. This has been reformed on May 23, 2019. It comprises a total of 9 people: one chairperson, one secretary, one treasurer, and 6 members. The committee is represented by all four villages (Simbrung, Syaksila, Lingam, and Mangkhim) in the valley.

SEED-SCALE Training

A SEED-SCALE (Self-Evaluation for Effective Decision-making-Systems for Communities to Adapt learning and Expand) training was held in Khandbari, Sankhuwasabha for three consecutive days in 2019 to encourage and empower the participants for creating three-way partnerships, their ownership, and engagement in the Project, and applied community change and sustainable development through learning and applying the SEED-SCALE concept. A total of 18 persons (9 Female and 9 Male) from the Local Coordination Committee, TEF, and different Community Forest Groups participated in the program.

The training has been successful to achieve a number of outcomes:

Photo 5: SEED-SCALE training in Khandabari, 2019

- The participants were really encouraged, enjoyed, and developed a practice to learn, share, work and grow together in the team.
- They were able to define their own community with conceptual clarity through the assessment of strengths, weaknesses, opportunities, and threats of their respective communities.
- They were able to learn, understand and internalize the concept, approach, and process of SEED-SCALE by adopting and applying its several steps such as four basic principles, seven tasks to sustain momentum, five criteria to assess progress, and three dimensions of scalability for their community empowerment and transformation.

They have developed a plan of action to promote, expand and scaling-up of SEED-SCALE concept for their community empowerment, social change, and transformation (for details see the Project's achievement report April 2019-September, 2019).

Climate Change Awareness Raising Training

Climate change awareness-raising training was conducted in Khandbari for three consecutive days in 2019 to introduce climate change and its impacts, and to prepare a climate-resilient plan using the LAPA (Local Adaptation Plan of Action) method. The training was accomplished in three stages:

1. talking about climate change and its impacts and noting down the climate change impacts of the past 30 years based on their knowledge,

2. drawing local maps to identify the key climate-prone areas and reasons how climate change can affect these areas, and

3. develop a key climate change adaptation and mitigation plan (for detail see Project's achievement report April 2019 - September 2019).

Photo 6: Participants in climate change training in Khandabari, 2019

Conclusion

The global temperature rising trend has resulted in the decade of the 21st century being the warmest, and consequently, its negative impacts on biodiversity and livelihood have been increasingly reported. These are expected to continue in the future. In this context, during the project period, a foundation was laid to collect regularly the ecological, meteorological, bioacoustics, and camera-trapped data for the long run; processing and analyzing of bioacoustics data was computerized by developing AI models, and educating the local communities about the climate change and its impacts upon their livelihoods, and developing mitigating and adapting plans to climate change along with community empowerment, social change, and transformation plans through SEED-SCALE concept was initiated.