

HEROES

(The Summary Report)

2015-2020





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Letter from the Director

HEROES (Himalayan Environmental Rhythm Observation and Evaluation System) is in the 7th year of its implementation. What started as a small-scale climate change impact monitoring on biodiversity has grown significantly over years, both in terms of its impact and outreach. HEROES involves 400 students (20 schools) observing 100 different species of wild plants and record their lifecycle events and their timing daily. In addition, students also manage the automatic weather station that logs data every 10 minutes.

Why schools? We believe that leadership begins in school, and a school is a place where we can make a lasting, impactful, and scalable investment for a sustainable future. In the face of global climate change, the next generation of citizens will ultimately face the brunt of climate change. We feel obliged to equip them with the necessary knowledge, skills, experiences, and efficacy to live harmoniously in an environment that they will inherit.

Unlike other climate monitoring sites, the HEROES project is unique: it trains the next generation of scientists right in the school backyard, it brings value-added and targeted learning experiences to the classroom, and bridges the gaps between scientists, researchers, and educationists. Bhutan lacks baseline observation data to understand how climate change will impact the nation's biodiversity. While we do have weather stations that provide climate data, we don't have any records of how our mountain landscapes respond to climate change. The usage of earth-observing satellite data is seriously challenged due to its highly complex topography. Even to make any reasonable inferences from satellite data analysis, it needs extensive validation using observation data. Basically, a yearly record of when plant's leaf sprouts, flower blooms, fruit ripen, etc, provides an immense value in understanding how our biodiversity is responding to climate change.

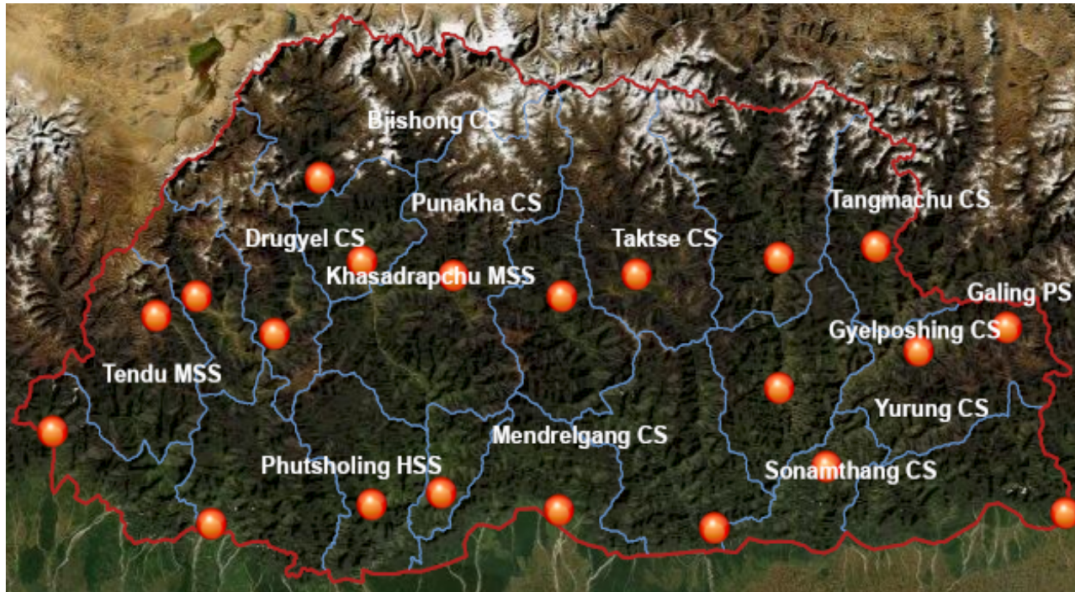
The project has generated 6 years of climate data from 20 sites and 100 species yearly lifecycle events and its timing daily. Such high-resolution data, especially the daily phenology records are generated for the first time in Bhutan. What excites us more is some of the insightful information that we can decode from few years of observation data. In this report, we are happy to share those preliminary findings. Significant progress was made, yet lots remain to be done to make HEROES a viable and robust climate change impact monitoring system in Bhutan.

So far, we have received strong support from all those involved in the project and we look forward to a similar kind of support in the future. We would like to thank the Karuna Foundation, Bhutan Foundation, and Ministry of Education for all those support.



(Director)
UWICER

About HEROES



Himalayan Environmental Rhythm Observation and Evaluation System (HEROES) is a citizen science initiative to monitor climate variability and its impact on the terrestrial ecosystem in Bhutan. It was established in 2015 to observe, record, store and share phenology data or information to enhance understanding of climate changes and their impact in Bhutan.

Phenology is widely used as a nature calendar - when the cherry tree blooms, when the black neck crane migrates, when farmers plant paddy, etc. These seasonal appearances are intricately linked to climatic conditions such as temperature, precipitation, and sunshine hours. Changes in phenological events such as the timing of budburst, flowering, etc are the most sensitive biological indicator of climate change. Basically, a yearly record of when plant's leaf sprouts, flower blooms, fruit ripen, etc, provides an immense value in understanding how biodiversity is responding to climate change.

Unlike other climate monitoring sites, the HEROES project is unique. It trains the next generation of scientists right in their school backyard. Also, it brings value-added and targeted learning experiences to the classroom and bridges the gaps between scientists, researchers, and educationists.

The project is implemented in 20 schools located across different forest types and geographic regions of the country. In addition, we have also established a network of weather stations at the same site where we monitor phenological events of plants on daily basis. This has enabled us to closely monitor how local variation in temperature and precipitation affects the timing of a plant's phenological events over years. Also, as the country forest types vary with elevation gradient, the project monitors different forest types located at different elevation gradients. The lowest elevation of the monitoring site is located in Phuntsholing at 200 m AMSL and the highest in Damthang at 3030 m AMSL.

2014 | The preparatory phase

- As the preparatory phase, UWICER had procured project equipment such as weather stations, desktop computers and cameras .
- The installation of weather stations in schools, distribution of desktop computers and cameras to 17 schools
- The development of database for phenology data submission, storage and archiving.



17

Weather stations operationalized benefiting about 10,000+ students on accessing daily weather information.

1

Online database development for phenology observations where 400+ students submit and store their data.

17

Computers and cameras supplied to schools that are used by 400+ students in schools.



2015 | The first year phase

- GIS lab established - 25 high spec desktop computer procured
- Procurements of the first conservation drone (eBee)
- Ex-country training program to 17 teachers, 1 MoE focals and 3 UWICER staffs



17

Teachers mentor 20-30 students each every year on phenology observation.

300+

Participants used the GIS lab for training conducted at the institute

10+

Drone services provided to various agencies to facilitate their decisions



2016 | The 2nd year phase

- HEROES mainstreamed into the Environmental Science curriculum.
- HEROES members students presented the HEROES' project research in the national STEM olympiad.
- The phenology mobile app was developed and launched online for usage by students.



3

Curriculums
standard mainstreamed
HEROES in Environmental
Science Curriculum

5

School used HEROES
data to study and present
their findings at National
Science Olympiad and
other projects.

10

Schools used mobile apps
to collect phenology
observation data



2017 | The 3rd year phase

- HEROES project had funded ex-country training for UWICER staff
- Funded teachers ex-country training on phenology
- Funded staff from other agencies (stakeholders) on ex-country training



28

UWICER staff capacity
developed

18

Teachers capacity
developed

11

Other stakeholders
capacity developed



2018 | The 4th year phase

- Environmental Science teachers trained on phenology observation protocols as part of their curriculum
- Additional schools added to the HEROES project making the total number of schools 20
- Students involved in the project since its start in 2015.



110

Schools in Bhutan started implementing phenology observation as part of their ES subject

1500+

Students engaged in the project activities since 2015

3

Additional schools joined the HEROES project in 2018



2019 | The 5th year phase

- The 2nd phase HEROES project MoU signed between GNHC and Bhutan Foundation
- Conducted scientist- students interactive talk on climate change and its impact (The IPCC Noble Laurates , Dr. Steven Running) - 210 students attended the talk
- HEREOES awarded the international The Energy GLOBE awards



2nd

Phase MoU signed for HEROES project between GNHC, BF and Karuna Foundation

210+

Students attended the scientific talk on 'Running through the science of climate change' delivered by Dr. Steven Running, University of Montana

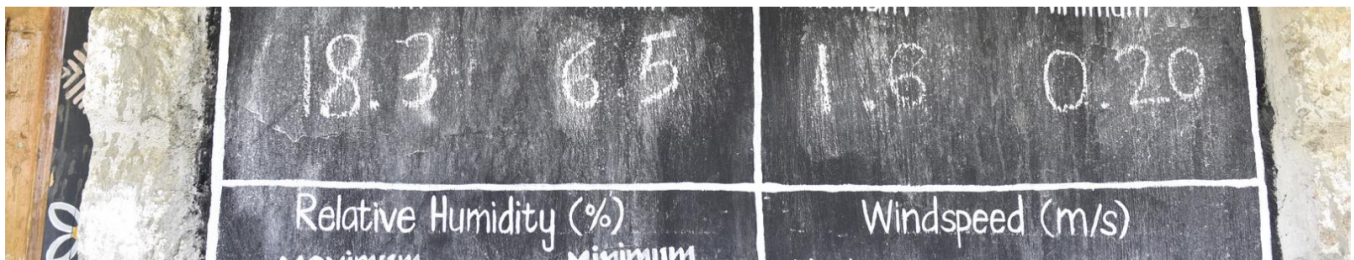
1st

Project in Bhutan to be awarded the Energy Globe Award for the involvement of youth in climate change studies



2020-2021 | The 6-7th year phase

- HEROES tied up with DEVELOP to carry out an in-depth analysis on phenology changes using satellite data
- HEROES - GLOBE collaboration on STEM engagement finalized
- Climate and phenology data analysis



20

Years of satellite data analysis to understand climate change impact on vegetation phenology in Bhutan.

2

International collaboration or network on climate change impact study in Bhutan.

6

Years climate and phenology data analysis of the HEROES project.

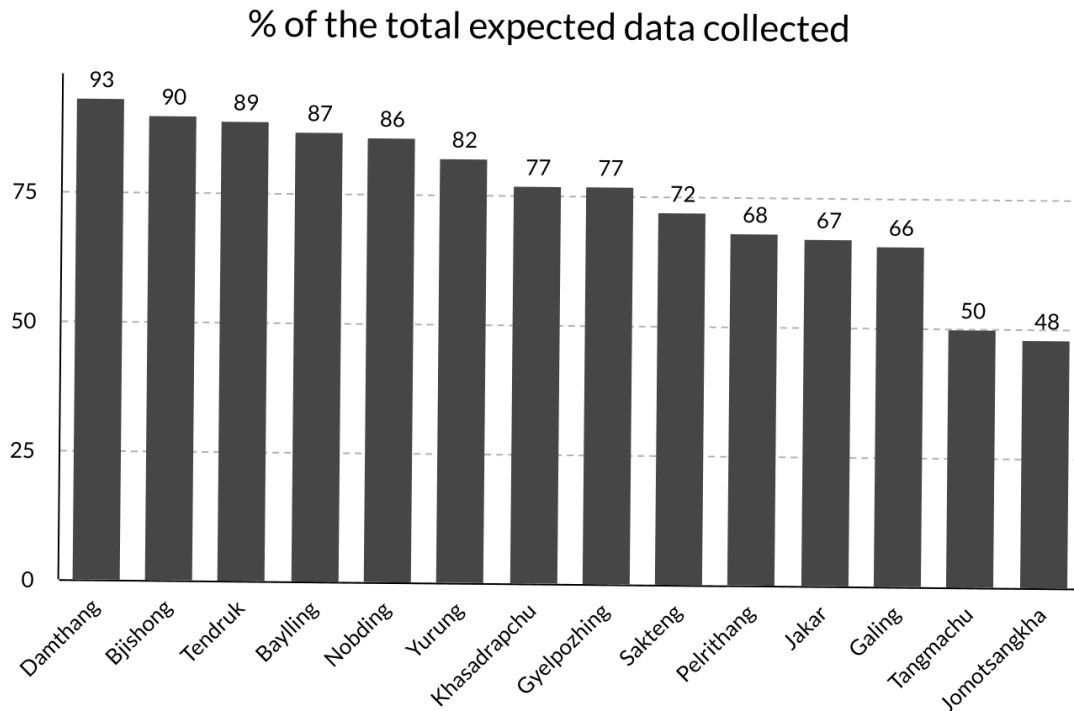


B. Climate and phenology data

Climate data counts

Accessing climate data at a relevant spatial and temporal scale is a major challenge in carrying out any climate change impact study. 20 weather stations have been installed in 20 schools to provide high-resolution climate data in 2014. 10 weather stations are web-based and the other 10 stations are standalone. These weather stations log weather parameters such as temperature, precipitation, solar radiation, soil moisture, wind speed, and wind direction every 10 minutes.

The weather stations were installed at the elevation range of 200 m in the south to 3900 m in the north.



Given 365 days of daily data in a year, each station is expected to collect the total daily records of 2190 days in 6 years. Those stations that have 2190 daily records were provided scores of 100% and those with no records the score of 0%.

Weather stations from 7 schools have collected and archived more than 90% of its total expected data. Stations from 3 schools have collected and archived more than 70% % of the total expected data. Four stations have collected data more than 50% of the total expected data. Data from Jomotsangkha and Tangmachu have major data gaps. The gaps were filled using the data from the nearest stations.

Data collection from 4 stations of Mendrelgang, Phuntsholing, Geserling and Jomotsangkha is non-consistent due to the discontinuation of the project from Mendrlgang since 2018 and station breakdown at Geserling , Phuntsholing and Jomotsangkha since 2018.

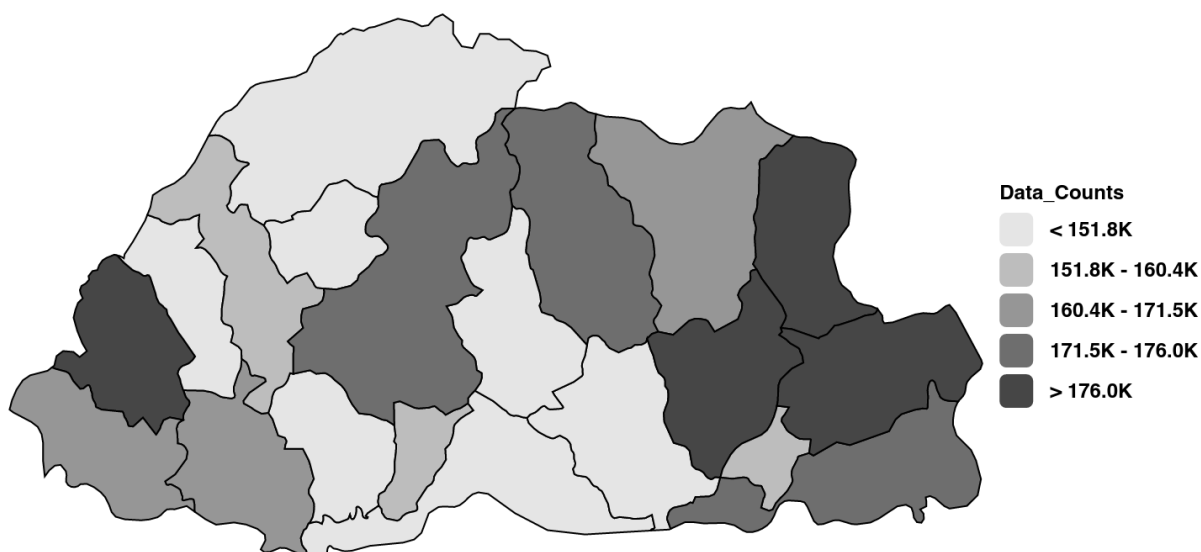
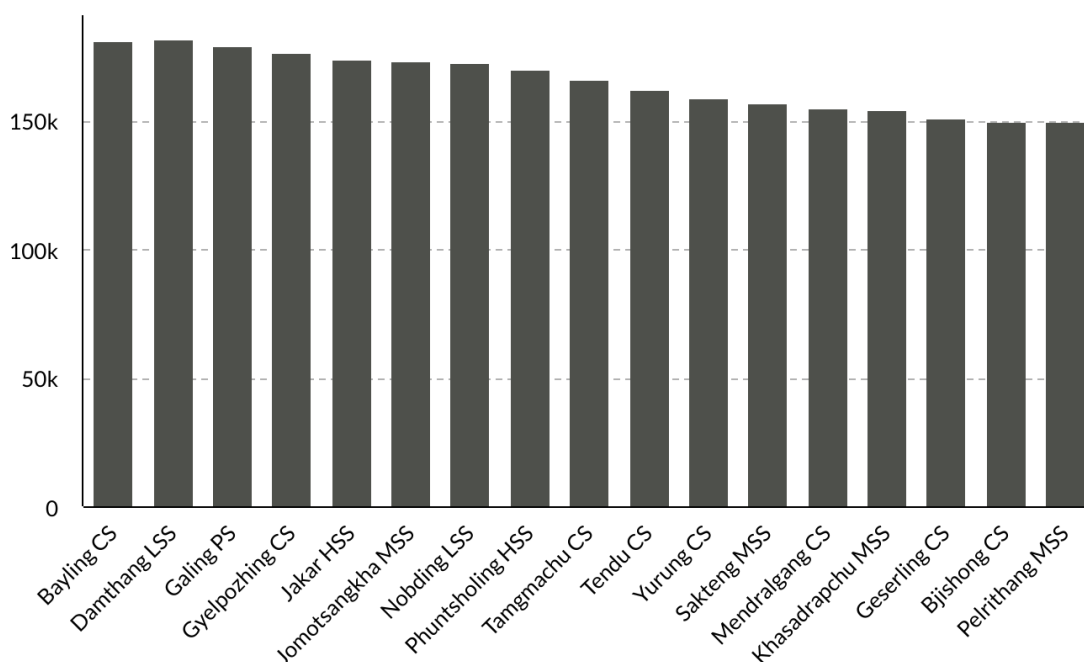
Data from three stations (Drugyel, Punakha, and Taktse) have not been included for analysis as they have been installed only in 2019 and have few years of data only.

Data from 8 stations out of 17 stations that have more than 75% of total data were directly analysed without any gap filling. 5 station's data that have more than 50% but less than 75% of the total data have been used after filling the data gap from nearby stations.

Phenology data counts

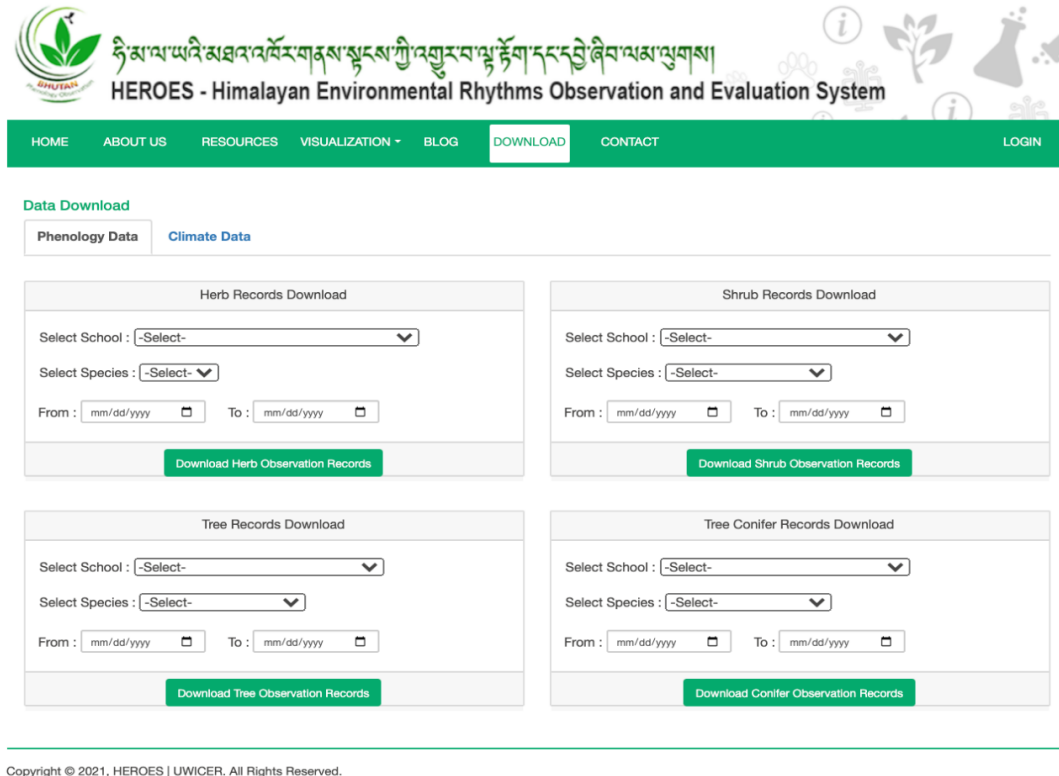
Each school has 10 plants under observation. The plants under observation are visited on daily basis and their phenophase recorded in the observation forms. In a year, plants are observed on daily basis for 10 months. In a year, each school generates daily observation records of 3000. 17 schools record and submitted 51,000 records in a year. Over 6 years, 2.8 million observation records have been submitted and archived in the project database.

Data_counts (6 years)

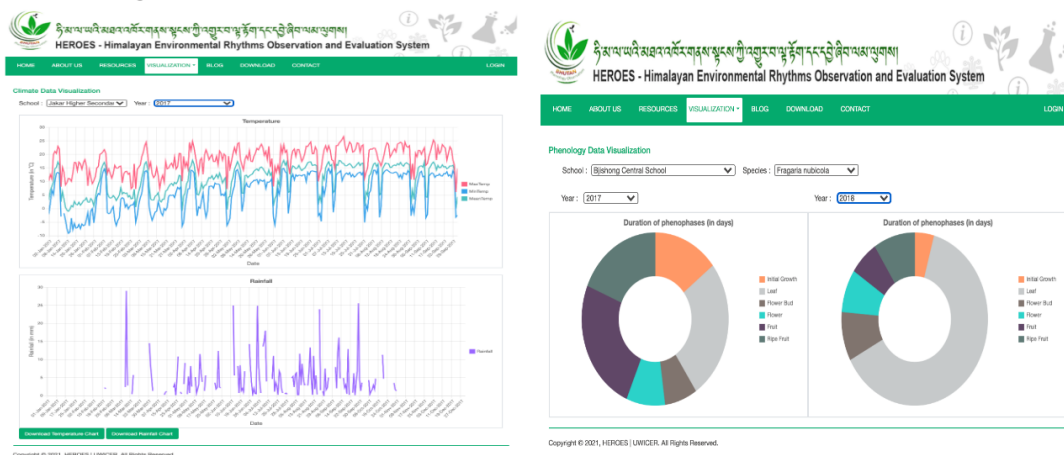


Data sharing and accessibility

Both climate and phenology data that has been generated over 6 years can be directly accessed from the project website (www.heroes.gov.bt). The data can be accessed at different spatial and temporal resolutions such as daily, monthly, and yearly for the specific site or for whole schools at one time. The web interface for the data access is as shown in the Figure below.



In addition, the users can visualize data either graphically or in tabular format by selecting the parameter using the drop-down menu button. The visualization can be exported in different graphical formats such as pdf, jpeg, png, etc. Also, using the tool, a simple analysis such as the linear relationship between the winter temperature and budburst onset can be carried in the web interface, and its result exported in different image format.













Data analysis summary

















Climate data

From the analysis of 13 stations, 8 stations (Bayling, Damthang, Galing, Jakar, Nobding, Pelrithang, Sakteng and Yurung) data shows a consistent trend of an average monthly temperature increase over years. From these stations, the monthly average temperature of Bjishong, Baylling, Damthang, Nobding, and Sakteng) has experienced the maximum increase. Galing and Jakar have experienced a slight increase in average monthly temperature over the year.

Jomotsangkha, Khasadrapchu, and Tedruk have recorded a decreasing average monthly temperature trend over the year. This indicates that these places have experienced cooler periods over the year. The rest of the stations (Bjishong and Gyelpozhing) didn't show any clear trend of warming or cooling over the year.

An overall analysis of precipitation data indicates that 9 (Bjishong, Bayling, Damthang, Galing, Jakar, Jomotsangkha, Nobding, Sakteng, and Tendruk) out of 13 stations have experienced an increasing precipitation trend over the year. Gyelpozhing, Khasadrapchu, and Yurung indicated a decreasing precipitation trend over years. Pelrithang didn't show any clear trend.

School	Temperature	Trend	Precipitation	Trend
Bjishong	The monthly mean maximum temperature didn't show any increasing or decreasing trend.		The monthly total maximum precipitation has increased from 226 mm in 2015 to 390 mm in 2018.	
Bayling	The monthly mean maximum temperature has increased from 17.35 degree Celsius in 2015 to 18.14 degree Celsius in 2018.		The monthly total maximum precipitation has increased from 150 mm in 2015 to 193.6 mm in 2018.	
Damthang	The monthly mean maximum temperature has increased from 14.75 degree Celsius in 2015 to 15.56 degree Celsius in August 2020.		The monthly total maximum precipitation has increased from 148 mm in 2015 to 285 mm in 2020.	
Galing	The monthly mean maximum temperature has increased from 20.82 degree Celsius in 2015 to 21.80 degree Celsius in 2020.		The monthly total maximum precipitation has increased from 263.00 mm in 2015 to 416.4 mm in 2020.	
Gyelpozhing	The monthly mean maximum temperature has increased from 24.5 degree Celsius in 2015 to 27.8 degree Celsius in 2018 and decreased to 22.46 degree Celsius in 2019.		The monthly total maximum precipitation has decreased from 190.00 mm in 2015 to 132 mm in 2018 and to 95 mm in 2019.	

School	Temperature	Trend	Precipitation	Trend
Jakar	The monthly mean maximum temperature has increased from 25.14 degree Celsius to 26.5 degree Celsius in 2020.		The monthly total maximum precipitation increased from 113 mm in 2015 to 314 mm in 2020.	
Jomotsangkha	The monthly mean maximum temperature has decreased from 22.68 degree Celsius in 2015 to 21.93 degree Celsius in 2020.		The monthly total maximum precipitation has increased from 410 mm in 2015 to 805 mm in 2020.	
Khasadrapchu	The monthly mean maximum temperature has decreased from 19.15 degree Celsius in 2015 to 17.84 degree Celsius in 2020.		The monthly total maximum precipitation has decreased from 87 mm in 2015 to 74.60 mm in 2020.	
Nobding	The monthly mean maximum temperature has increased from 14.13 degree Celsius in 2015 to 14.28 degree Celsius in 2020.		The monthly total maximum precipitation has increased from 246 mm in 2015 to 269 mm in 2020.	
Pelrithang	The monthly mean maximum temperature has increased from 25.77 degree Celsius in 2015 to 26.08 degree Celsius in 2020.		Due to rainfall sensor failure, precipitation data has lot of data gap and not suitable for analysis	
Sakteng	The monthly mean maximum temperature has increased from 11.15 degree Celsius in 2015 to 12.75 degree Celsius in 2020.		The monthly total maximum precipitation has increased from 142 mm in 2015 to 335.00 mm in 2020.	
Tendruk	The monthly mean maximum temperature has decreased from 23.66 degree Celsius in 2015 to 22.70 degree Celsius in 2020.		The monthly total maximum precipitation has increased from 512 mm in 2015 to 987.00 mm in 2020.	
Yurung	The monthly mean maximum temperature has increased from 21.79 degree Celsius in 2015 to 22.19 degree Celsius in 2020.		The monthly total maximum precipitation has decreased from 630.73 mm in 2015 to 345.2 mm in 2020.	

Phenology data

The phenology observations data include phenophase status records of presence ('Yes') and absence ('No'). The phenology observation data have been checked for their qualities in terms of data continuity and reliability. Out of 10 species data from each school, one species data from each school was selected for analysis. For the analysis, phenophases stages such as initial growth, budburst, and open flower were selected as these phenophases are easier to identify due to their distinctive nature.

During an analysis, the first onset date of initial growth, budburst, and flowering for the selected species were compared for different years. From this, the changes (delay or advance) in the date of the first events were computed. Similarly, the duration of these phenophases (budburst and flower) in each year was calculated, and changes were recorded. The results of the analysis were as tabulated below:

Schools	Species	Phenophase	Observation
Bjishong	Eleagnus parviflora (Silver berry)	Open flower ↓	In 2020, flowering happen 27 days latter than 2015
Bayling	Quercus grifithii (Oak)	Budburst ↑	In 2020, the budburst happened 17 days earlier than 2015.
Damthang	Rosa sericea (Wild rose)	Budburst ↑	in 2020, the budburst happened 24 days earlier than 2015.
Galing	Prunus persica (Peach)	Budburst ↑	In 2020, the budburst happened 11 days earlier than that of 2015.
Gyelpozhing	Melia azederach (Persian lilac)	Budburst ↓	In 2018, the budburst happened 3 days latter than that of 2015.
Jakar	Primula debticulata (Primerose)	Initial growth ↑	in 2020, the initial growth happened 2 days earlier than that of 2015.
Jomotsangkha	Bombax ceiba (Cotton tree)	Budburst ↓	In 2020, the budburst happened 7 days latter than that of 2015.
Khasadrapchu	Prunus persica (Peach)	Open flower ↑	In 2020, the flowering happened 2 days earlier than that of 2015.
Nobding	Berberis asiatica	Open flower ↓	In 2020, the flowering happened 5 days latter than that of 2015.
Pelrithang	Bidens pillosa (Beggerstick)	Initial growth ↑	In 2020, the initial growth happened 28 days earlier than that of 2015.
Sakteng	Fragaria nubicola (Wild strawberry)	Initial growth ↑	in 2019, initial sprouting happened 8 days earlier than that of 2015.
Tendruk	Mangifera indica (Mango)	Budburst ↓	In 2017, the budburst happened 17 days latter than that of 2015.
Yurung	Eleagnus parviflora (Silver berry)	Open flower ↑	In 2018, the flowering happened 7 days earlier than 2015.

Capacity building activities

HEROES project had supported 28 capacity development sessions of UWICER staff. These staff are involved in the implementation of project activities. Though some staff has been transferred to other agencies, most of the staff are still at the Institute and they help in the implementation of the project activities. In addition, the project had also supported an ex-country training program for 19 teachers in 2014. The details of staff who have benefited from the project in terms of their capacity development since the project initiation are tabulated below:

UWICER Staff

Year	Name	Organization	Training	Period	Cuntry
2018	Sangay Pelzang, IT Officer	UWICER	Msc in GIS	2018-2019	Australia
2017	Sangay Zangmo, IT Associate	UWICER	Database training	10-18/9/2017	Philippines
2017	Kinzang Wangdi, Technician	UWICER	Weather station management	10-18/9/2017	Philippines
2017	Pema Lhazom, Ass.Librarian	UWICER	Information management course	10-18/9/2017	Philippines
2017	Tshering Dhendup, Ass.Media Officer	UWICER	Photography training	4-1/12/2017	Thailand
2016	Changa Tshering, Forestry Officer	UWICER	Drone training	15-19/2/2016	Australia
2016	Tashi Choden, IT Officer	UWICER	Data managemant	13-26, June, 2016	Australia
2016	Manisha Subbha, Statistician	UWICER	Data analysis	15/7- 5/8/2016	Netherland
2015	Sonam Wangdi, Librarian	UWICER	Outreach and education strategies	13-23/3/2015	USA
2015	Wangchuk Dorji, Forestry Officer	UWICER	Monitoring training	28-29/4/2015	Azerbaijan
2015	Sangay Zangmo, IT Associate	UWICER	Network system	1-18/01/2015	Malaysia
2015	Kinley Dema, Office Assistant	UWICER	Office management	3-16/01/2015	Philippines
2014	Changa Tshering, Forestry Officer	UWICER	Satellite image processing	4/8-18/5/2014	Australia
2014	Dechen Tshomo, ADM	UWICER	Project management	22/10-8/11/2014	Philippines
2014	Tenzin Chogay, Forestry Officer	UWICER	Study visit with focal teachers	15-23/12/2014	Thailand

UWICER Staff

Year	Name	Organization	Training	Period	Cuntry
2014	Kezang Wangchuk, Forestry Officer	UWICER	Study visit with focal teachers	15-23/12/2014	Thailand
2014	Rinchen Namgay, Forestry Officer	UWICER	Institutional visit	4-13/11/2014	Thailand
2014	Rinchen Singye, Sr.Forester	UWICER	Institutional visit	4-13/11/2014	Thailand
2014	Tshethup Tshering	UWICER	Study visit with focal teachers	15-23/12/2014	Thailand
2014	Sangay Pelzang, IT Officer	UWICER	Training on GIS and GPS	9/6/- 4/7/2014	Nepal
2013	Nawang Norbu, Director	UWICER	Phenology visit and MoU with UNE	15-19/2/2013	Australia
2013	Sangay Wangchuk, Forestry Officer	UWICER	Phenology and MoU with UNE	15-19/2/2013	Australia
2013	Tshering Dhendup, Media Officer	UWICER	Graphic Design	5-21/8/2013	Philippines
2013	Choki Lham, Asst.Forester	UWICER	Weather station management	7-12/9/2013	Thailand
2013	Choney Wangmo, Ass.ADM	UWICER	Weather station management	7-12/9/2013	Thailand
2013	Pema Lhazom, Ass.Librarian	UWICER	Weather station management	7-12/9/2013	Thailand
2013	Dawa Dema, Office Assistant	UWICER	Office management	7-12/9/2013	Thailand
2013	Rinzin Gyeltshen, Accountant	UWICER	Project management	7-12/9/2013	Thailand
2013	Dorji Wangdi, OA	UWICER	Project management	7-12/9/2013	Thailand

Teachers

Year	Name	Organization	Training	Period	Cuntry
2014	Tek Bhadur Rana, Teacher	Geserling Central School	Study visit on HEROES	15-23/12/2014	Thailand
2014	Tashi Wangchuk, Teacher	Tangmachu Central School	Study visit on HEROES	15-23/12/2014	Thailand
2014	Sonam Rinchen, Teacher	Tendruk Central School	Study visit on HEROES	15-23/12/2014	Thailand
2014	Dorji Khandu, Teacher	Damthang Primary school	Study visit on HEROES	15-23/12/2014	Thailand
2014	Mani Bidha, Teacher	Nobding MSS	Study visit on HEROES	15-23/12/2014	Thailand
2014	Sonam Zangmo, Teacher	Phuntsholing HSS	Study visit on HEROES	15-23/12/2014	Thailand
2014	Rinchen Phuntsho, Teacher	Sakteng MSS	Study visit on HEROES	15-23/12/2014	Thailand
2014	Melan Dorji, Teacher	Yurung Central School	Study visit on HEROES	15-23/12/2014	Thailand
2014	Duba Tshering, Teacher	Galing PS	Study visit on HEROES	15-23/12/2014	Thailand
2014	Mohan Chettri, Teacher	Jakar HSS	Study visit on HEROES	15-23/12/2014	Thailand
2014	Kelzang Choki, Teacher	Meldrealgang CS	Study visit on HEROES	15-23/12/2014	Thailand
2014	Yeshi Wangdi, Teacher	Jomotsangkha CS	Study visit on HEROES	15-23/12/2014	Thailand
2014	Kinga, Teacher	Bjishong CS	Study visit on HEROES	15-23/12/2014	Thailand
2014	Pema Rinzin, Teacher	Pelrithang CS	Study visit on HEROES	15-23/12/2014	Thailand
2014	Ugyen Lhamo, Teacher	Bayling CS	Study visit on HEROES	15-23/12/2014	Thailand
2014	Tashi Dema, Teacher	Gyelpozhing CS	Study visit on HEROES	15-23/12/2014	Thailand
2014	Rupak Sharma, Teacher	Khasadrapchu MSS	Study visit on HEROES	15-23/12/2014	Thailand
2014	Desang Dorji, Program Officer	Ministry of Education	Study visit on HEROES	15-23/12/2014	Thailand

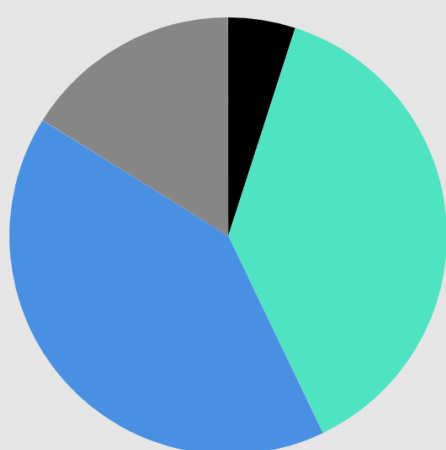
Others (DOFPS and DoA)

Year	Name	Organization	Training	Period	Cuntry
2015	Gyelong Drukpa, Agricultural Officer	Bumthang District Agriculture Officer	Agriculture crop phenology training	10-24/3/2015	Japan
2014	Karchung Drukpa, Sr.Forester	Trashigang Division	Institutional visit	1-10/12/2014	Thailand
2014	Gombir Rai, Forester	Sarpang Division	Institutional visit	1-10/11/2014	Thailand
2014	Cencho Nidup, Forester Ranger	Sarpang Division	Institutional visit	1-10/11/2014	Thailand
2014	Sonam Tshering, Forester	Sarpang Division	Study visit on HEROES	1-10/11/2014	Thailand
2014	Leki Dorji, Forester	Sarpang Division	Study visit on HEROES	1-10/11/2014	Thailand
2014	Mani Ram Chettri, Sr.Forester	Tsirang Division	Study visit on HEROES	1-10/11/2014	Thailand
2014	R.B.Thapa, Asst.Forester	Tsirang Division	Study visit on HEROES	1-10/11/2014	Thailand
2014	Kaka Dorji, Sr.Forester	Samtse Division	Study visit on HEROES	1-10/11/2014	Thailand
2014	Karma Jigme, Forest Ranger	Thimphu Division	Study visit on HEROES	1-10/11/2014	Thailand

Financial overview

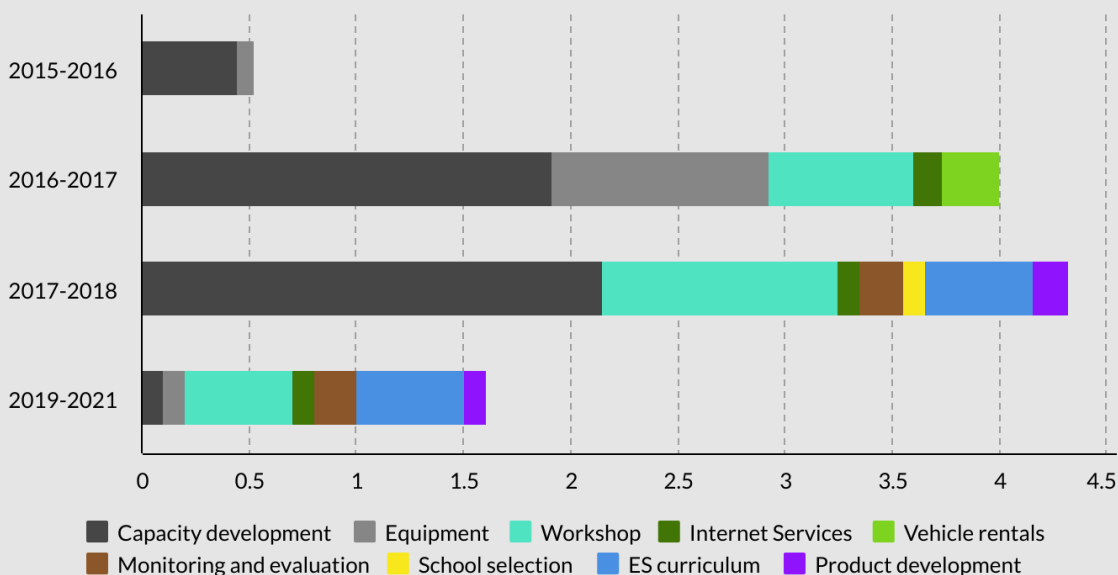
Budget release and the expences status

Since 2014, HEROES was funded by KARUNA FOUNDATION through Bhutan Foundation. Untill 2015, the fund was directly released to UWICER. However with the signing of MoU between Bhutan Foundation, GNHC and UWICER in 2016, the fund was routed through GNHC. This report, therefore, only present the overall financial standing from 2015 onward. However, the year wise reporting, both financial and physical, had already been submitted to Bhutan Foundation through GNHC.



BUDGET		Nu(Million)
	2015-2016	0.524
	2016-2017	4.001
	2017-2018	4.328
	2019-2021	1.720
Total		10.573

EXPENCES in Nu (Million)



PARTNERS

Funder and implementer

Partners are key to the success of HEROES. Together with partners, HEROES has made significant progress towards fulfilling its core objectives.

HEROES team is grateful to our funders, the KARUNA FOUNDATION, and the BHUTAN FOUNDATION. Without their committed support, HEROES wouldn't have materialized.

We are also grateful to the network of schools, teachers, and students who are part of the HEROES. Their hard work and enthusiasm have not only helped to establish the baseline data for climate change study but also set the benchmark of climate literacy in Bhutan.

As part of mainstreaming HEROES in the school's curriculum, Royal Education Council (REC) has played a critical role in facilitating the incorporation of phenology as one of the topics in the Environmental Science Curriculum. We would like to thank REC for all the support.

Implementation of activities wouldn't have been possible without the timely release of funds. We are also grateful to GNHC for making the fund available on time and for the guidance during the overall implementation of the project.

KARUNA
FOUNDATION



Ugyen Wangchuck Institute for Conservation and Environment

Official Address

Ugyen Wangchuck Institute for Conservation and
Environmental Research (UWICER)
Department of Forests and Park Services
Ministry of Agriculture and Forests
Lamai Goempa, Bumthang
Web Address: www.uwice.gov.bt
Post Box No. : 155
PABX No. : +975-03-631926
Fax No. : + 975-03-631925

**For any inquiries/information, please drop an
email to the address below**

Email ID: info@uwice.gov.bt

Web Master

Tashi Choden
Email ID: tchoden@uwice.gov.bt