S SCIENCE

T TECHNOLOGY

E ENGINEERING

M MATHEMATICS

Education and Research

18 - 28 February 2024

APN ASIA-PACIFIC NETWORK FOR GLOBAL CHANGE RESEARCH

FULBRIGHT

NDRI नेपाल विकास अनुसन्धान प्रतिष्ठान Nepal Development Research Institute

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THE SMALL EARTH NEPAL-2001

Objective

To understand the general overview of STEM education in Nepal: Challenges, solutions, and opportunities

Implement the National Science Foundation (NSF) best practice Model Institutions for Excellence (MIE), Saturday Research Academy (SRA), using modern AI technology in the early scientific research process in STEM fields

Provide strategies for encouraging critical thinking, problem-solving, and creativity among students, helping them develop skills that are crucial for STEM fields

To build up a network of researchers within Nepal and international and establish as a knowledge-sharing and learning forum, for future collaborations.

Fulbright Specialist Dr. Juan F. Arratia

- Research Professor and Mentor
- Principal Investigator of the Model Institutions for Excellence (MIE) Project
- Founder and President of Scientific Caribbean Foundation, San Juan, Puerto Rico, USA
- Recipient of 2007's Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring

Engaging Nepalese in STEM education and research: Capacity building workshop and research symposium

Every day for 2 to 3 hours meeting with Dr. Juan, where Dr. Juan mentors research cycle and help develop a competitive scientific posters students wishes to do his research

Similar to Saturday Research Academy (SRA)

12 Selected Participants were selected from diverse field (Meteorology, Environmental Science, Civil Engineering, Forestry, Agriculture, IT, Zoology and Biomedical Engineering)

Inauguration of STEM Workshop:

- UN House, February 18, 2024
- With around 48 participants workshop was formally inaugurated by distinguished guests , who presented remarks on the priorities of Nepal's STEM education and research, its current status, and the potential for utilizing best practices such as MIE program to strengthen the field of STEM.

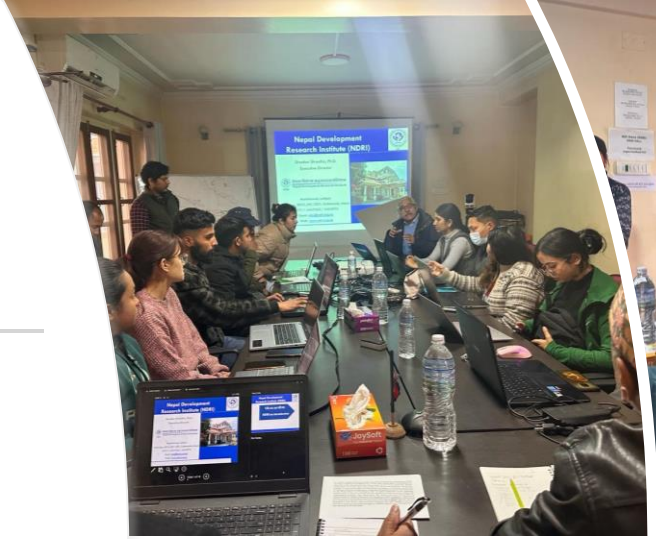
Young Scientist Summit 2024 Demonstration

- Demonstration from 11 students of 6 different school under the following themes
- Computer Science including AI (CS)
- Life Science
- Engineering and Robotics
- Indigenous Knowledge and Technology (IKT)
- Chemical and Environmental Sciences
- Physical Sciences and Mathematics

STEM Workshop: A journey of peer-learning

- Peer learning and review of each steps of research cycle

- Guest lectures and discussions from the Professors from IOE and IOF and Professionals from NDRI, UNESCO, UCES and SEN



Empowering the Future Leaders in STEM through School Level

- 26th February at Kathmandu Pragya Kunja School (KPKS), New Baneshwor, Kathmandu
- Interactive session with twenty-seven students from grades 7 and 9
- Dr. Arratia delivered an informative presentation to the students, showcasing the significance of STEM fields and research
- He engaged in a dialogue with the students, exploring their aspirations and research interests. Dr. Arratia imparted valuable insights into how students can pursue research in their chosen fields

Talk program on “STEM and Opportunities of Engagement in the International Research Network”

- Discussed about the MIE, NSF and SRA
- Research opportunities in STEM field
- Questions and answers.
- Attended by 50 individuals that included students, professors, journalists, and early career researchers

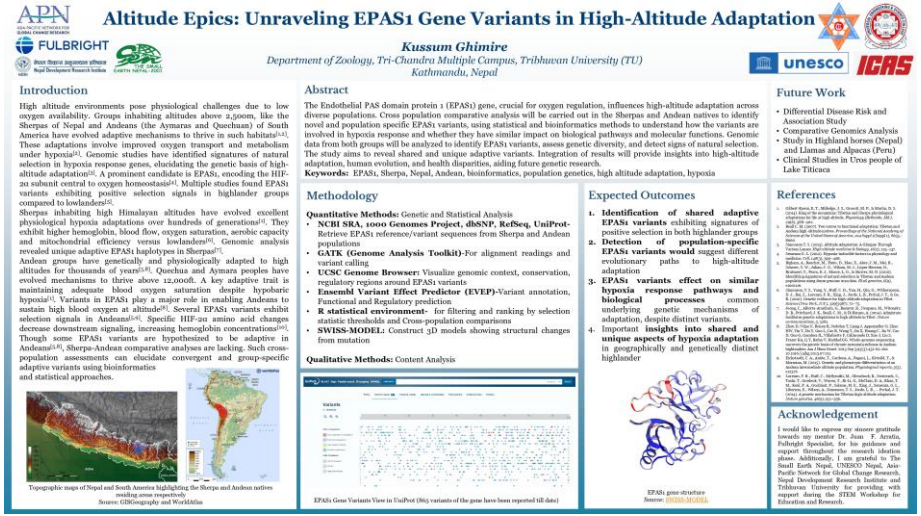
Research Symposium and Closing Ceremony

- Provided the students an opportunity to have a conference like experience

- 9 Participants presented their scientific poster

- They are still being mentored by Dr. Juan and will again present at a virtual international seminar at end of May 2024

Participant's Research Titles



Altitude Epics: Unraveling EPAS1 Gene Variants in High-Altitude Adaptation

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Kathmandu, Nepal

Introduction

High altitude environments pose physiological challenges due to low oxygen availability. Groups inhabiting altitudes above 2,500m, like the Sherpas of Nepal and Andeans (the Aymaras and Quechuan) of South America have evolved adaptive mechanisms to thrive in such habitats[1,2]. These adaptations involve improved oxygen transport and metabolism under hypoxia[2]. Genomic studies have identified signatures of natural selection in hypoxia response genes, elucidating the genetic basis of high-altitude adaptation[2]. A prominent candidate is EPAS1, encoding the HIF-2α subunit central to oxygen homeostasis[4]. Multiple studies found EPAS1 variants exhibiting positive selection signals in highlander groups compared to lowlanders[2].

Sherpas inhabiting high Himalayan altitudes have evolved excellent physiological hypoxia adaptations over hundreds of generations[3]. They exhibit higher hemoglobin, blood flow, oxygen saturation, aerobic capacity and mitochondrial efficiency versus lowlanders[3]. Genomic analysis revealed unique adaptive EPAS1 haplotypes in Sherpas[3].

Andean groups have genetically and physiologically adapted to high altitudes for thousands of years[1,5]. Quechua and Aymara peoples have evolved mechanisms to thrive above 12,000ft. A key adaptive trait is maintaining adequate blood oxygen saturation despite hypobaric hypoxia[1]. Variants in EPAS1 play a major role in enabling Andeans to sustain high blood oxygen at altitude[5]. Several EPAS1 variants exhibit selection signals in Andeans[2,5]. Specific HIF-2α amino acid changes decrease downstream signaling, increasing hemoglobin concentrations[2,5]. Though some EPAS1 variants are hypothesized to be adaptive in Andeans[2,5], Sherpa-Andean comparative analyses are lacking. Such cross-population assessments can elucidate convergent and group-specific adaptive variants using bioinformatics and statistical approaches.

Topographic maps of Nepal and South America highlighting the Sherpa and Andean natives residing areas respectively.
Source: GISGeography and WorldAtlas

Abstract

The Endothelial PAS domain protein 1 (EPAS1) gene, crucial for oxygen regulation, influences high-altitude adaptation across diverse populations. Cross population comparative analysis will be carried out in the Sherpas and Andean natives to identify novel and population specific EPAS1 variants, using statistical and bioinformatics methods to understand how the variants are involved in hypoxia response and whether they have similar impact on biological pathways and molecular functions. Genomic data from both groups will be analyzed to identify EPAS1 variants, assess genetic diversity, and detect signs of natural selection. The study aims to reveal shared and unique adaptive variants. Integration of results will provide insights into high-altitude adaptation, human evolution, and health disparities, aiding future genetic research.

Keywords: EPAS1, Sherpa, Nepal, Andean, bioinformatics, population genetics, high altitude adaptation, hypoxia

Methodology

Quantitative Methods: Genetic and Statistical Analysis

- **NCBI SRA, 1000 Genomes Project, dbSNP, RefSeq, UniProt-** Retrieve EPAS1 reference/variant sequences from Sherpa and Andean populations
- **GATK (Genome Analysis Toolkit)-**For alignment readings and variant calling
- **UCSC Genome Browser:** Visualize genomic context, conservation, regulatory regions around EPAS1 variants
- **Ensembl Variant Effect Predictor (EVEP)-**Variant annotation, Functional and Regulatory prediction
- **R statistical environment-** for filtering and ranking by selection statistic thresholds and Cross-population comparisons
- **SWISS-MODEL:** Construct 3D models showing structural changes from mutation

Qualitative Methods: Content Analysis

EPAS1 Gene Variants View in UniProt (866 variants of the gene have been reported till date)

Expected Outcomes

1. **Identification of shared adaptive EPAS1 variants** exhibiting signatures of positive selection in both highlander groups
2. **Detection of population-specific EPAS1 variants would** suggest different evolutionary paths to high-altitude adaptation
3. **EPAS1 variants effect on similar hypoxia response pathways and biological processes** common underlying genetic mechanisms of adaptation, despite distinct variants.
4. Important **insights into shared and unique aspects of hypoxia adaptation** in geographically and genetically distinct highlander

EPAS1 gene structure
Source: SWISS-MODEL

Future Work

- Differential Disease Risk and Association Study
- Comparative Genomics Analysis
- Study in Highland horses (Nepal) and Llamas and Alpacas (Peru)
- Clinical Studies in Uros people of Lake Titicaca

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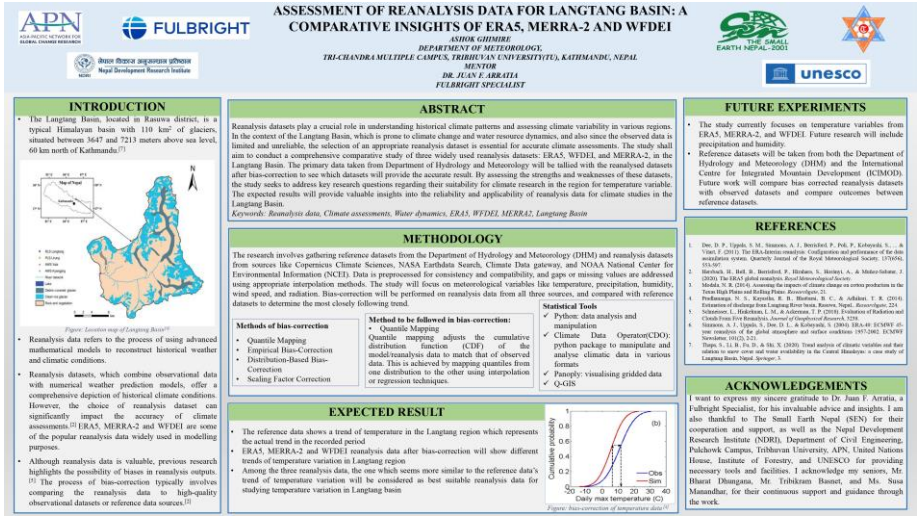
- “Altitude Epics: Unraveling EPAS1 Gene Variants in High-Altitude Adaptation” Kussum Ghimire ,Department of Zoology, Tri-Chandra Multiple Campus, Tribhuvan University, Kathmandu, Nepal
- “Assessment of Reanalysis Data for Langtang Basin: A Comparative Insights of ERA5, MERRA-2 and WFDEI” Ashok Ghimire, Department of Meteorology, Tri-Chandra Multiple Campus, Tribhuvan University, Kathmandu, Nepal
- “Analysis of Microplastics Across Varied Soil Types in Kathmandu Valley, Nepal" Prativa Dawadi, Department of Environmental Science, Tribhuvan University, Nepal
- “Effect of Biochar enriched with urine on soil fertility and maize productivity in Chitwan, Nepal” Selina Mainali, Institute of Agriculture and Animal Science(IAAS), Rampur Campus, Tribhuvan University(TU), Chitwan, Nepal

Participant's Research Titles



ASSESSMENT OF REANALYSIS DATA FOR LANGTANG BASIN: A COMPARATIVE INSIGHTS OF ERA5, MERRA-2 AND WFDEI

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ABSTRACT

Reanalysis datasets play a crucial role in understanding historical climate patterns and assessing climate variability in various regions. In the context of the Langtang Basin, which is prone to climate change and water resource dynamics, and also since the observed data is limited and unreliable, the selection of an appropriate reanalysis dataset is essential for accurate climate assessments. The study shall aim to conduct a comprehensive comparative study of three widely used reanalysis datasets: ERA5, WFDEI, and MERRA-2, in the Langtang Basin. The primary data taken from Department of Hydrology and Meteorology will be tallied with the reanalysed datasets after bias-correction to see which datasets will provide the accurate result. By assessing the strengths and weaknesses of these datasets, the study seeks to address key research questions regarding their suitability for climate research in the region for temperature variable. The expected results will provide valuable insights into the reliability and applicability of reanalysis data for climate studies in the Langtang Basin.

Keywords: Reanalysis data, Climate assessments, Water dynamics, ERA5, WFDEI, MERRA2, Langtang Basin

INTRODUCTION

- The Langtang Basin, located in Rasuwa district, is a typical Himalayan basin with 110 km² of glaciers, situated between 3647 and 7213 meters above sea level, 60 km north of Kathmandu.[1]

Figure: Location map of Langtang Basin[1]

- Reanalysis data refers to the process of using advanced mathematical models to reconstruct historical weather and climatic conditions.
- Reanalysis datasets, which combine observational data with numerical weather prediction models, offer a comprehensive depiction of historical climate conditions. However, the choice of reanalysis dataset can significantly impact the accuracy of climate assessments.[2] ERA5, MERRA-2 and WFDEI are some of the popular reanalysis data widely used in modelling purposes.
- Although reanalysis data is valuable, previous research highlights the possibility of biases in reanalysis outputs. [3] The process of bias-correction typically involves comparing the reanalysis data to high-quality observational datasets or reference data sources.[3]

METHODOLOGY

The research involves gathering reference datasets from the Department of Hydrology and Meteorology (DHM) and reanalysis datasets from sources like Copernicus Climate Sciences, NASA Earthdata Search, Climate Data gateway, and NOAA National Center for Environmental Information (NCEI). Data is preprocessed for consistency and compatibility, and gaps or missing values are addressed using appropriate interpolation methods. The study will focus on meteorological variables like temperature, precipitation, humidity, wind speed, and radiation. Bias-correction will be performed on reanalysis data from all three sources, and compared with reference datasets to determine the most closely following trend.

Methods of bias-correction

- Quantile Mapping
- Empirical Bias-Correction
- Distribution-Based Bias-Correction
- Scaling Factor Correction

Method to be followed in bias-correction:

- Quantile Mapping

Quantile mapping adjusts the cumulative distribution function (CDF) of the model/reanalysis data to match that of observed data. This is achieved by mapping quantiles from one distribution to the other using interpolation or regression techniques.

Statistical Tools

- ✓ Python: data analysis and manipulation
- ✓ Climate Data Operator(CDO): python package to manipulate and analyse climatic data in various formats
- ✓ Panoply: visualising gridded data
- ✓ Q-GIS

EXPECTED RESULT

- The reference data shows a trend of temperature in the Langtang region which represents the actual trend in the recorded period
- ERA5, MERRA-2 and WFDEI reanalysis data after bias-correction will show different trends of temperature variation in Langtang region
- Among the three reanalysis data, the one which seems more similar to the reference data's trend of temperature variation will be considered as best suitable reanalysis data for studying temperature variation in Langtang basin

Figure: bias-correction of temperature data[4]

FUTURE EXPERIMENTS

- The study currently focuses on temperature variables from ERA5, MERRA-2, and WFDEI. Future research will include precipitation and humidity.
- Reference datasets will be taken from both the Department of Hydrology and Meteorology (DHM) and the International Centre for Integrated Mountain Development (ICIMOD). Future work will compare bias corrected reanalysis datasets with observed datasets and compare outcomes between reference datasets.

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- "Enhancement of Building Code of Nepal with insights from Japanese and Chile Codes" Rajan Kumar Sah, Department of Civil Engineering, Thapathali Campus, TribhuvanUniversity,Kathmandu, Nepal
- "Examining the Precision and Dependability of the Reanalysis Data for Temperature in the Imja Glacier" Sushant Dhital, Department of Meteorology, Tri-Chandra Multiple Campus, Tribhuvan University, Kathmandu, Nepal
- "Long-Term Effects of Human-wildlife conflict on Bird Population in Meghauli, Chitwan" Seemran Budhathoki, Kathmandu Forestry College, Tribhuvan University, Nepal
- "Comparative analysis of telomeres dynamics between homo sapiens, Asian elephant and Himalayan field mice" Bhushant Pradhanaga, College of Biomedical Engineering and Applied Sciences, Purbanchal University
- "Performance evaluation of Reanalysis datasets of precipitation variable in Khumbu Glacier" Aakriti Dhakal, Department of Meteorology, Tri-Chandra Multiple Campus, Tribhuvan University, Kathmandu, Nepal
- "Enhancement of Building Code of Nepal with insights from Japanese and Chile Codes" Rajan Kumar Sah, Department of Civil Engineering, Thapathali Campus, TribhuvanUniversity,Kathmandu, Nepal

Certificate Distributions

Student's Testimonials

- "We need more of this workshop and mentorship to make us realize we can do proper research from early stage." - Kussum Ghimire

- "I had the honour of participating in the STEM research session, and I have to say that it was a priceless learning opportunity. The workshop has influenced how I approach communication and research, giving me the ability to make a significant contribution to STEM." - Ashok Ghimire

Thank you
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