Glaciers and Students:
A Scientific Approach to Monitor Climate and Glaciers in Pakistan's Mountain Regions to support Hydrogeological Risk Prevention

Annual Progress Report- APR 2022

July 2022– December 2022

UNDP Project ID: 00144462

ACRONYMS

AOI	Area of Interest
CKNP	Central Karakoram National Park
DMA	Disaster Management Authority
EPA	Environmental Protection Agency
ESA	European Space Agency
GADM	Global Administrative Data and Maps
GB	Gilgit Baltistan
GBDMA	Gilgit Baltistan Disaster Management Authority
GLOF	Glacial Lake Outburst Flood
GIS	Geographic Information System
GLIMS	Global Land Ice Measurements from Space
HW	Hardware
ICIMOD	International Centre for Integrated Mountain Development
JAXA	Japan Aerospace Exploration Agency
KIU	Karakoram International University
NASA	National Aeronautics and Space
SUPARCO	Space and Upper Atmosphere Research Commission of Pakistan
SW	Software
UNDP	United Nations Development Programme
UNICA	University of Cagliari
UNIMI	University of Milan
UOBS	University of Baltistan Skardu

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Unit Snapshot

Project Brief Description and Outputs:

The northern parts of Pakistan are home to some of the vast stretches of glaciers after the northern pole. The glacier reserves feed local livelihood systems and support unique ecosystems of global importance, in addition to serve as source of water for downstream areas. In face of the growing threat from global warming, these resources need assessment and monitoring through scientific technologies. The people living in mountain slopes of GB region are faced with risk of mountain hazards originating from glacier changes under the effect of climate change. The lack of information on climate change and assessment of glacial changes makes it difficult to predict the hazards. This project aims at developing a consolidating program to establish monitoring of high-altitude climate and assessment of glacier changes, in support of environmental monitoring and natural resources management in Pakistan Mountains, Project activities contribute to improve risk assessment and prevention, dealing in particular with GLOFs and hydrogeological hazard, through application of remote sensing and GIS techniques and a dedicated web information system. The project actively involves Pakistan Universities and their students in the monitoring activities through a dedicated training and capacity building program in the field of glaciers monitoring activities and remote sensing analysis to provide the appropriate tools to ensure the pursuing of a long-term research activities at the end of the project.

The project has two outputs;

Output 1: Assessment and monitoring system of mountain glaciers and climate improved in Pakistan mountain areas contributing to improved planning and management of water and natural resources including the sustenance of biological diversity and support to local livelihood base.

Output 2: Collaboration and sharing mechanism among Pakistani and international institutions and students strengthened to build capacities for longer term glaciers monitoring through innovative approaches and technologies

The project duration is till December 2023.

Overall Unit Quality Rating (mark on the scale of 1 to 5 as per the following criteria):				
Exemplary (5) *****	High (4) ****	Satisfactory (3) ***	Poor (2) **	Inadequate (1) *
All outputs are rated High or Exemplary	All outputs are rated Satisfactory or higher, and at least two criteria are rated High or Exemplary	One output may be rated Poor, and all other criteria are rated Satisfactory or higher	Two outputs are rated Poor, and all other criteria are rated Satisfactory or higher	One output is rated Inadequate, or more than two criteria are rated Poor

Budget 2022	454, 647 USD
Expenditure 2022	404, 255.95 USD (Including GMS 8% of 29748.31)
Delivery %	88.9%

1. Introduction

Mountain glaciers worldwide are reported to be generally receding. Impacts of climate change on global and regional ice-mass fluctuations are poorly understood because of complex feedback mechanisms and the shortage of good field or laboratory assessments. The Karakoram was identified as a critical region for such a study. Its glaciers are thought to be particularly sensitive to climate forcing due to high altitudes. The Karakoram Himalayas contain some of the longest and largest valley glaciers of the world outside high latitudes, and through their glacier melt, provide more than 60 per cent of the Indus River flow. The study of these glaciers is thus crucial for ensuring water security in Pakistan.

In alignment with this situation, Glaciers and Students Project aims at preventing hydrogeological-related risks and hazards in GB and establish an evidence-based assessment and monitoring system for the mountain glaciers with active involvement of international and regional academia, line departments and dedicated capacity-building program for the long-term sustainability of the project interventions. The annual reports cover the progress under Glaciers and Students for July 2022 to December 2022.

Followed by the project kickoff meeting and inception workshop in August 2022, field activities were initiated with several other planned interventions. Key achievements made under the project during the reporting period include:

- Installation of 03 Automated Weather Stations (AWS) in Passu, Ghulkin and Shisper glaciers and reinstallation of 01 AWS in Askole
- Data was acquired from AWS and various glacial inventory reports and Satellite images
- The infrastructure for the processing of satellite images was finalized and is being used for data sharing, visualization, and validation.
- The criteria for glaciers identification and mapping of the glaciers boundaries and population of the database, on the whole Area of Interest (AOI) finalized and tested.
- AWS restoration survey on Baltoro region from Askole to Concordia.
- Multitemporal and field analysis of 04 glaciers and glacial bodies.
- Trainings for total 212 participants including students, researchers and govt officials (incl. 99 females and 113 males) from Karakorum International University (KIU), University of Baltistan Skardu (UOBS) and EPA-GB for glaciological field activities and GIS .
- Existing GB GeoApp was upgraded and tested in Baltistan and Gilgit regions during the second phase.
- 3 MoUs for KIU, EPA and UoBs drafted and shared with the universities.

1.1 Progress towards CPD Outcome

The project contributes to CPD Outcome 2 (UNSDF Outcome 6): Enhanced Resilience and Socioeconomic Development of Communities, and Output 6.3: Legal and regulatory frameworks and policies are in place, and institutions are capacitated for the conservation, sustainable use,

inclusive access and benefit-sharing of natural resources, biodiversity, chemicals, waste management and ecosystems. The project has enhanced resilience of the local communities and improved planning of local institutions through installation of automated weather stations. The multitemporal field investigations of 04 glaciers will contribute to development of Glacial inventory for the region, hence providing authentic research findings for climate resilient planning at local level. Two training were also provided to 212 students and faculty members on using GeoApp and AWS installation and Data collection for capacity building.

1.2 Overall Project Progress 2022

Overall progress of the project from July 2022-December 2022 is mentioned below;

1.2.1 Automated Weather Stations Installation and restoration

Under the project, to ensure a reliable weather monitoring network in Pakistan and Gilgit-Baltistan at high altitudes, 3 weather stations were installed in Upper Hunza on Passu, Ghulkin and Shispar Glaciers and 01 existing AWS reinstalled (relocated the weather station at Askole village to the CKNP premises at Askole Maidan due to security issues). Two permanent AWS were successfully installed one each in Borith Lake area and Shishper Glacier including the installation of temporary AWS at Gulkin & Passu Glacier respectively. Ablation stacks were also installed at Shishper Glacier to measure ice melt and relate it to meteorological variables, particularly air temperature, and solar radiation. The permanent AWS was installed to collect important weather data which can be used to investigate the conditions leading to the formation of the glacier lake and GLOFs.

AWS restoration survey from Askole village and over Baltoro region was carried out, the conditions of existing AWSs at 03 sites were assessed and the inventory of equipment of these stations were developed. The 03 sites were Askole, Urdukas and Concordia. However, according to the survey, it was found that the AWS at Concordia no longer exists. Hence, it was suggested to install a brand-new AWS at the site with proper sustainability mechanisms. In AWS survey, 04 consultative sessions were arranged with CKNP management and its field staff, and the communities of Askole and Urdukas. In the last quarter of 2022, the acquisition of metadata from newly installed AWS was also carried out. (E1 and E2).

1.2.2 Multitemporal and Field investigations on 04 glaciers

Multitemporal and field investigations on 04 glaciers (Passu, Batura, Ghulkin and Shispar) in Hunza basin were kicked off. The glaciers were selected through a literature review and thorough consultations. Glaciological field missions were organized to carryout field investigations for the 04 glaciers, including the installation of the automatic weather stations, and installation of ablation stakes on both clean and debris-covered ice, to understand the melt patterns of these glaciers and the differences between melt of debris-free and debris-covered glaciers. Furthermore, glaciers were also studied to assess the presence of different contaminants on these glaciers. Afterwards, the methodology was tested on a defined area while optimizing the process of identification and delimitation. To assess the glacier change, important data was acquired from the University of Milan, satellite images and digital elevation models to verify accuracy of these products. (E3)

1.2.3 Development of outline for glacier inventory

The outline for the glacier inventory was developed and during this reporting period, the architecture of the data processing system was discussed and implemented. To guarantee the access and sharing of the data between the involved students and experts of the working group during the project, and in the future to all interested people, a server was configurated and the space of external storage was dedicated. A working group with dedicated skills was formed with involvement of international universities to produce the new data in an GIS interactive environment. Furthermore, satellite images were acquired to develop new glacier inventory and to improve mapping. (E4)

1.2.4 GBGeo App updated

The GBGeo App was checked in field to evaluate its existing condition and subsequently upgraded for the implementation of information system. New Points of Interest (POIs) were developed and added into the app. In developing the information system, the main focus in this period was the design of the database on RDBMS Postgres with the help of the Post GIS extension for geometric components. The data structures were designed to store the information intended to be collected in the field through the aid of a multi-platform app developed and hoc. A REST api layer was designed on the identified data model, extended with the data structures necessary to manage the app's functionalities (including user registration/authentication management), as an integration layer between the app and the backend components. (E5)

1.2.5 Training on field monitoring and glacier inventory

During the first phase of the project, the training or capacity building were implemented at KIU, EPA-GB, and UoBs to ensure long-term sustainability of the project. During the second phase of the project, participants were trained in 02 events arranged by EvK2CNR and UNICA on the operation of the GeoApp. Collectively, in both the quarters, 212 participants were trained, including 99 females. In the first training 43 participants (33 male participants and 10 female) attended training on AWS installation, data collection and maintenance. The second training was held on GIS and remote sensing training for 169 participants (80 male and 89 females). Furthermore, in the last quarter, avalanche training manual has also been drafted for training to be conducted in 2023. (E6, E7, E8, E9, E10, E11, and E12)

1.2.6 MoUs

03 MoUs were drafted and shared with the relevant institutions including KIU, EPA and UoBs. It involves coordinated research and training activities in the fields of Glaciology and GIS. (E13)

2. Situation analysis

2.1. Time Constraint

During the project, the dedicated time for preparation, planning and implementation of field activities was very short. To reduce this problem, Implementing Partner (EvK2CNR Italy) along with its partners, including EPA-GB, started the glaciological field activities in advance prior to the detailed multitemporal analysis to avail the full summer session for field surveys, glacier studies and installation of AWS.

2.2. Weather and Geographic conditions

Glacial terrains are risky and difficult to work in and this becomes more challenging when working with a large team. To tackle this issue, glacier rescue, tracking, climbing and use of equipment and ropes was organized on the specific study sites. Due to the risks of extreme weather conditions, weather conditions and meteorological forecasts were closely monitored before planning field activities and close liaison was maintained before proceeding on field trips. The field installations (e.g. the Automatic weather Stations at high altitudes) was regularly monitored for damages through using local guides. If any damages did occur to the apparatus after weather calamities or climatic events, it was promptly repaired/replaced. Furthermore, to avoid delay of assessments and field trips due to extreme weather conditions, automatic apparatus was used for recording the data to be downloaded after longer periods of time.

2.3. Logistic Issue

Conducting field missions on glaciers is a difficult task as it is, with an added hurdle of logistics. To mitigate this issue, a recognition team from IP visited the field area prior to the mission to have real time information. Based on that, accommodation was arranged in nearby guest houses and camping on glacial fields. All the team members were provided with packed lunch and water while on the mission.

2.4. AWS not Protected

After the installation of the 03 weather stations, concerns were raised on how protected the stations were at the sites. Based on this, it was suggested to fence the new weather stations installed to ensure long-term sustainability. However, there was no change to resolve the issue.

2.5. Delay in Issuance of NOCs

The delay in issuance of NOCs for expat experts to work in the project field sites was a major implementation challenge. To resolve this issue, all NOC processes were started well before the specific intervention. The project document was shared with GB Home Department for their information and consent, to ensure smooth proceedings. Close liaison was maintained with security personnel in the region and were consulted on field activities and movement in the field. The Environmental Protection Agency, under the GB Forest, Wildlife & Environment Department were consulted on the project design documents well in advance through LPAC and as part of the local coordination forums. Proper formalities for expats movement were carried out to avoid further delays, e.g., all NOCs were fulfilled.

2.6. COVID-19

Health restrictions due to COVID-19 were an issue in the implementation of the project, however, appropriate measures were adopted to mitigate health risks. The SoPs e.g., health screening, lockdown, travel restrictions and social distancing were strictly followed.

3. Performance and results

3.1. Contribution towards CPD Outputs

CPD Output 6.3: Legal and regulatory frameworks and policies are in place, and institutions capacitated for the conservation, sustainable use, inclusive access and benefit-sharing of natural resources, biodiversity, chemicals, waste management and ecosystems			
Indicator(s):	**Baseline:**	**Target(s):**	**Achievement(s):**
6.3.2 Extent to which disaster and climate-risk management plans and implementation measures at national and provincial levels are inclusive and effective (e.g., including the collection of disaggregated data, gender analysis and targeted actions). **Strategic Plan IRRF 3.1.2** Number of countries with early warning and preparedness measures in place to manage impact of conflicts, disasters, pandemics and other shocks	Scale: 1. Not adequately	Scale: 4. Largely	UNDP has installed 03 Automated Weather Stations, reinstalled an existing station from which metadata was acquired for glacier change assessment. Furthermore, an outline and methodology were developed for the publication of the Pakistan Glacier Inventory and GB GeoApp was upgraded, released, and tested. All these interventions are done to help the government of Pakistan in resilient planning for the future regarding natural hazards.

Description of CPD Output level <u>results achieved</u> in 2022:

To ensure a reliable weather monitoring network in Pakistan and Gilgit-Baltistan at high altitudes, 03 weather stations were installed in Upper Hunza on Passu, Ghulkin and Shispar and 01 existing AWS reinstalled in CKNP premises in Askole Maidan. The activity included Installation of 01 permanent automatic weather station between Passu and Ghulkin, 01 temporary automatic weather station on the Passu glacier and installation of ablation stakes at different locations to measure ice melt and relate it to meteorological variables, particularly including air temperature, solar radiation, 01 temporary automatic weather station on the Ghulkin glacier and installation of ablation stakes as described for Passu Glacier, and installation of 01 permanent automatic weather station on the Shispar glacier forefield, to collect important weather data which can be used to investigate the conditions leading to the formation of the glacier lake and GLOFs.

AWS restoration survey from Askole village and over Baltoro region has also been carried out, the existing conditions of AWSs at 03 sites were assessed and the inventory of equipment of these stations were developed. In the last quarter of 2022, the acquisition of meta data from newly installed AWS was carried out.

Moreover, the outline for the glacier inventory was developed and during this reporting period, the architecture of the data processing system was discussed and implemented. To guarantee the access

and sharing of the data between the involved students and experts of the working group during the project, and in the future to all interested people, a server was configurated and the space of external storage was dedicated. A working group with dedicated skills was formed with involvement of international universities to produce the new data in an GIS interactive environment. In the last quarter, satellite images were acquired to develop new glacier inventory and to improve mapping. A report on glacier inventory was also developed that describes the contents of the Glaciers Inventory database.

The GBGeo App was checked in field to evaluate its existing condition and subsequently upgraded for the implementation of information system. New Points of Interest (POIs) were developed and added into the app. In developing the information system, the main focus in this period was the design of the database on RDBMS Postgres with the help of the Post GIS extension for geometric components. The data structures were designed to store the information intended to be collected in the field through the aid of a multi-platform app developed and hoc. A REST api layer was designed on the identified data model, extended with the data structures necessary to manage the app's functionalities (including user registration/authentication management), as an integration layer between the app and the backend components.

Means of Verification

E1: Installation of AWS
E2: Field reports on AWS Installation
E3: Pakistan Glacier Inventory
E4: GB GeoApp Activity Report

3.2: Progress towards Project Outputs

Output I: Assessment and monitoring system of mountain glaciers and climate improved in Pakistan contributing to improved planning and management of water resources and natural resources including the sustenance of biological diversity			
Indicator(s):	**Baseline:**	**Target(s):**	**Achievement(s):**
1.1: Number of climate monitoring stations in glacier region established and maintained to provide data on changing climate patterns for use by MET Dept. and other concerned	3 Automatic Weather Stations exist	08 (By Dec 2023)	04 (03 new AWS installed, and one old AWS reinstalled)
1.2 Number of glacial bodies measured, monitored and documented to monitor changes over time that can provide early warning for	0	04 (By Dec 2023)	04 (Glaciological missions carried out on 4 different glaciers in Hunza Basin)

natural hazards and contribute to reducing risks faced by mountain communities, particularly women and marginalized groups, in downstream valleys			
Indicator 1.3: Update the Pakistan Glacier Inventory	0	04 (Update Pakistan Glacier Inventory, Publication of 03 scientific research articles by Dec 2023)	01 (Outline and methodology for development of Glacier inventory formulated)

Description of Output level results achieved in 2022

In the Baltistan region, three standard automatic weather stations were installed in 2004, 2005 and 2011. During this project, all three stations were maintained and further improved by EvK2CNR. Under output 1, a restoration survey was conducted in which the inventory of equipment of the two automatic weather stations was developed at Urdukas, and Askole. After the survey, a stakeholder consultation was held to request CKNP HQ and management to allow CKNP officials to relocate the weather station at Askole village to the CKNP premises at Askole Maidan due to security and safety concerns, for which they were granted permission. Later, two meetings were arranged by EvK2CNR with the community of the village and field staff regarding the condition of the weather station at Askole village. Community and CKNP field staff were of the view of appointing a chowkidar to take care of the stations. They also emphasized fencing the station properly, moreover, they stressed awareness raising through CKNP staff and community activists regarding the importance and sensitivity of these stations. Additionally, new automatic weather stations were also installed to better investigate the relationship between on-glacier and off-glacier meteorological variables. The permanent weather stations were installed on the forefield of the glaciers, one between Passu and Ghulkin and one on Shispar, while the temporary weather stations were installed on-glacier on Passu and Ghulkin glaciers.

Under the first activity, metadata was acquired from the newly installed AWS to carry out the glacier area change assessment to be used for the report regarding the assessment.

The second activity under the output was divided into two aspects: multitemporal analysis and field monitoring. In multitemporal analysis, to identify the most appropriate glaciers for the glaciological mission, a literature review was carried out, by investigating papers available to the scientific community and reports from NGOs, along with a publication of CKNP on inventory of glaciers was also used. The field survey was done to update the estimates using improved methodologies stemming from accurate meteorological field and ice melt observations and newly accessible remote sensing data. The selected glaciers were of the Hunza Valley as the literature review shows that glaciers in the area are in balance with the climate, with reduced retreat rates and very frequent glacier surges, also posing risk of GLOFs from ice or moraine dammed lakes and outburst of subglacial water. In Hunza Valley, glacier termini reach close to the Karakorum highway, which means these events can damage road

infrastructure. Hence, it was impertinent to study these glaciers to avoid further calamities as much as possible. Field investigations were planned for these glaciers, including the installation of ablation stakes on both clean and debris-covered ice, to understand the melt patterns of these glaciers and the differences between melt of debris-free and debris-covered glaciers. Assessing the presence of different contaminants on these glaciers was also done. The target contaminants were microplastics (MPs) and Black Carbon (BC). Depending on the kind of glacier (debris covered or white), samples were planned to be collected from different debris matrices: sparse fine debris, cryoconite, dirt cones. As a side activity, sampling of cryoconite holes was performed on white glaciers.

Glacier inventories remain the most complete approach to investigate the status of glaciers at a given time; the glacier outlines from the inventories can then be used to estimate the total amount of freshwater stored within the glaciers as well as estimate the current meltwater produced by the glaciers and predict its future patterns. Inventories, already done, represent past glacier conditions (2000-2005), and some were created without the involvement of local researchers, likely missing important knowledge to increase their accuracy, which is particularly relevant in case of debris-covered glaciers, which are numerous in the Karakorum region, and notoriously difficult to map. For these reasons, the generation of an inventory of all Pakistani glaciers was required. The inventory represents as recent as possible glacier conditions and was created using the most recent remote sensing data and techniques, to generate an accurate product that can be used by all stakeholders as a baseline for the assessment of glacier freshwater resources and climate change impacts.

This activity was dedicated to the definition of criteria (methodology) for glacier identification and mapping (manual and/or semi-automatic) on a test area and definition of the final Area of Interest (AOI), considering the province of Gilgit-Baltistan. The application of existing methodologies improved by innovative methods for the integration of data from different sources (optical, thermal and active RS) was tested on a preliminary area. Furthermore, to assure that the methodology can be applied with the same accuracy and rules, training materials were prepared by the team and shared with all mapping participants (students and experts). A report on glacier inventory was also developed that describes the contents of the Glaciers Inventory database.

In the last quarter, the design and management of the infrastructure (software and hardware) for the processing of satellite images was implemented with the aim of producing the new geo-data from satellite data access, image processing, semi-automatic classification, and validation of the final features. Moreover, this system was done for the data sharing and for the visualization and validation of the data during the project. The resulting data was stored and is accessible from web through a dedicated Cloud-Drive. Moreover, the architecture of the data processing system was discussed and implemented. To guarantee the access and sharing of the data between the involved students and experts of the working group during the project, and in the future to all interested people, a server was configurated and the space of external storage was dedicated. A new Data Storage System has also been installed and configurated to guarantee the uploading and downloading of the available and new data.

Overall Output Status (mark the output on the scale of 1 to 5 as per the following criteria):				
Exemplary (5) *****	**High (4)** ****	**Satisfactory (3)** ***	**Poor (2)** **	**Inadequate (1)** *
The Unit is expected to over-achieve targeted outputs and/or expected levels of quality, and there is evidence that outputs are contributing to targeted outcomes	The Unit is expected to over-achieve targeted outputs and/or expected levels of quality	The Unit is expected to achieve targeted outputs with expected levels of quality	The Unit is expected to partially achieve targeted outputs, with less than expected levels of quality	Unit outputs will likely not be achieved and/or are not likely to be effective in supporting the achievement of targeted outcomes

Means of Verification

E1: Installation of AWS
E2: Field reports on AWS Installation
E3: Multitemporal Analysis and Field Monitoring
E4: Pakistan Glacier Inventory

Output II: Collaboration and sharing mechanism among Pakistani and international institutions and students strengthened to build capacities for longer term glaciers monitoring through innovative approaches and technologies.			
Indicator(s):	**Baseline:**	**Target(s):**	**Achievement(s):**
2.1: Web based GIS climate and glaciers data archiving and sharing system developed and maintained to enable knowledge and data sharing among the authorities responsible e.g., Met Deptt, Disaster Management Authorities, Agriculture Deptt, Water Mgt. Deptt & EPA at GB and national level.	0	1 number of systematic web-based GIS data archiving and sharing mechanism exist (By end of 2023)	01 (The condition of the existing GBGeo APP is being upgraded and POI was developed and incorporated into the app)

2.2: Number of students and faculty members of the local universities in Gilgit-Baltistan trained in glacier inventory and monitoring	0	100 by end of 2023 with 40% female participation	212 students, researchers and govt officials were trained (incl. 99 females)

Descriptions of outputs achieved in 2022

The first step of this output was to check the condition of the existing GBGeoAPP, developed earlier in 2019, whether the app is working correctly or not. Second, it was planned to collect information as Points of Interest (POI) which was developed into a new section and edited into the app. Eight main topics have also been added such as landslide, river, lake, glaciers, peak, vegetation, village and cultural heritage. The activities carried out also involved the design, installation and configuration of the technology stack. This update release of the app is working and is available for installation.

It was agreed to conduct a training to be delivered online and in asynchronous mode (i.e., through pre-recorded lectures) to maximize the number of people who could follow the course in view of possible electricity and connection issues. The topics ranged from weather instruments to an introduction to glaciology, principles of remote sensing, including types of satellite platforms, electromagnetic radiation and its interaction with the atmosphere, an introduction to the QGIS software for processing remote sensing and glaciological data and practical exercises on the use of QGIS.

In the second part of the output, a workshop was held at KIU, which included two presentations: one on the project “glaciers & students’ and the other on the glacier meteorology, automatic weather stations and weather instruments. The workshop was attended by students from KIU as well as UoBs. A second meeting at the KIU was held to receive feedback from students and faculty members concerning the activities carried out on the field, their expectations, and future suggestions. The meeting also included a discussion about GLOF and potential interesting glaciers to study for the fieldwork activities in next year. Furthermore, the meeting also included feedback on the training course. At the time, a limited number of students had received access to the course, as some of the emails which were shared turned out to be misspelled. The link to the meeting was therefore shared again with participants.

During the second quarter, the testing of the new version of the App was done. The aim of this activity was the analysis of the requests for the updating of the existing GB GeoApp. The new options and the contents of the new database were discussed during the meetings in Italy and online with the Italian and Pakistan partners, and lastly, new requests were collected during the training at Skardu and Gilgit. This activity was planned as a specific action of the two-day training at the universities at Skardu and Gilgit; the first training took place in Skardu, which was dedicated to the learning and testing of the GBGeoApp, starting from its installation into the mobiles of each student. The second training/testing at Gilgit confirmed the good performance of the application in the field.

In the second quarter of the output, a training avalanche risk module was developed along with a specific sub-module on devoted to the risk of glacier lake outburst floods (GLOF). The main topics of the avalanche risk module include snow cover evolution and stability, snow avalanche classification, snow avalanche forecasting, and snow avalanche risk management.

Moreover, a meeting was held with local researchers for monitoring activities in which the focus was to figure out the current status of the glaciers, and if the glaciers are receding or advancing, gaining or melting. The team members collected data from the AWS and made the necessary repair and maintenance work. Lastly, International Mountain Day was celebrated at KIU jointly organized by Karakoram International University and EvK2CNR. In which wall a climbing competition was also organized.

A total of 212 participants *(99 females)* attended the above-mentioned trainings.

Overall Output Status (mark the output on the scale of 1 to 5 as per the following criteria):				
Exemplary (5) *****	**High (4)** ****	**Satisfactory (3)** ***	**Poor (2)** **	**Inadequate (1)** *
The Unit is expected to over-achieve targeted outputs and/or expected levels of quality, and there is evidence that outputs are contributing to targeted outcomes	The Unit is expected to over-achieve targeted outputs and/or expected levels of quality	The Unit is expected to achieve targeted outputs with expected levels of quality	The Unit is expected to partially achieve targeted outputs, with less than expected levels of quality	Unit outputs will likely not be achieved and/or are not likely to be effective in supporting the achievement of targeted outcomes

Means of Verification

E5: GB GeoApp Activity Report
E6: Inception workshop
E7: Training and Orientation of Field mission
E8: Training for Geomatics and Glaciological Activities
E9: Training Attendees in Second Quarter
E10: Project Kick-off meeting
E11: Local researchers for monitoring activities
E12: Avalanche Risk module
E14: International Mountain Day

4. Lessons Learnt

Pertaining to the issues mentioned before, the lessons learnt for this project are as follows:

1. Organizing the field actives in advance in order to avail the summer season for glacier inventory and multitemporal analysis, was important to achieve the project in due timeline. In the future, if any activity can be done prior to implementation, it should be carried out.

2. To protect the glaciers from further harm, research should be turned to policies to contain black carbon emissions.
3. To ensure smooth proceedings, liaising and coordination with local universities should be given more time and more meeting should be conducted.
4. Student participation in the trainings did not meet the expectations. The reason could be absence of focal departments, difficult in internet connectivity or that glacier study is a new subject. In the future, more coordinated efforts should be made to ensure active participation.
5. The newly installed AWS needs to be fenced and more awareness sessions need to be held regarding the sensitivity and importance of the stations.

5. Evaluation

Evaluation is planned in 2023.

6. The way forward/ key Priorities For 2023

In 2023, the following actions have been planned under the following activities:

→ **Activity 1.1:** The automated weather stations installed will be checked and maintained along with a high-altitude meteorological observation system and monitoring network being completely in place.

→ **Activity 1.2a:** Under multitemporal analysis, glacier area change assessment will be carried out in the next year, leading to the publication of its report.

→ **Activity 1.2b:** Under field monitoring of glaciers, in the next year, validation and elaboration of acquired data will be carried out along with field mission on selected glaciers and data sharing.

→ **Activity 1.3:** In the activity regarding Pakistan Glacier inventory, in the year 2023 classified map will be finalized. Glacier bodies will be monitored implying in-situ measurements and remote sensing techniques and the data generated over a period will be used to establish a link between climate variations and glacier changes. The information will be periodically processed and validated for the publication

→ **Activity 2.1:** For implementation of information system, in 2023 SHARE Geonetwork platform will be updated and publication of the new web-service with new high-altitude weather stations data will also be carried out.

→ **Activity 2.2:** Under capacity building, training for GEOMATICS and avalanche risk will be executed in 2023.

7. Annexures

Annex 1: AWP 2022 based Reporting Matrix

EXPECTED OUTPUTS *And baseline, associated indicators and annual targets*	**PLANNED ACTIVITIES (as per AWP)**	**Activity Status** *Completed, Ongoing, Delayed, Cancelled*	**AWP Budget ($)**	**Expenditure ($)**	**% Delivery**
Output 1: Assessment and monitoring system of mountain glaciers and the climate improved in Pakistan mountain areas contributing to improved planning and management of water and natural resources including the sustenance of biological diversity and support to local livelihood base.					
Indicator 1.1: Number of climate monitoring stations in glacier region established and maintained to provide data on changing climate patterns for use by MET Deptt and other concerned *Target:* 08 AWS installed	**Activity Result 1.1: Climate monitoring network (installation and maintenance)**				
	Activity 1.1.1: Recognition survey at Askole and Urdukas station	Completed	15,806	15,036	95%
	Activity 1.1.2: Planning and installation of weather station restoration activities	Completed	34,457	35,105	102%
	Activity 1.1.3: Weather station restoration at Askole and Urdukas	Planned in 2023			
	Activity 1.1.4: Weather station checking and maintenance	Planned in 2023			
	Activity 1.1.5: Data provision and sharing	Planned in 2023			
Indicator 1.2: Number of glacial bodies measured, monitored and documented to monitor changes over time that can provide early warning for natural hazards and	**Activity Result 1.2a: Study and monitoring of glaciers and glacial bodies a) MULTI-TEMPORAL ANALYSIS**				
	Activity Result 1.2.1a: Selection of areas for multitemporal glacier analysis	Completed	7,165	6,820	95%

contribute in reducing risks faced by mountain communities, particularly women and marginalized groups, in downstream valleys *Target: 4 (number of new glaciers and glacial bodies monitored and studied)*	Activity Result 1.2.2a: Data acquisition for glacier area change assessment	Completed	7,165	7,399	103%
	Action 1.2.3a: Glacier area change assessment	Planned in 2023			
	Activity 1.2.4a: Change assessment report	Planned in 2023			
	Activity Result 1.2b: Study and monitoring of glaciers and glacial bodies b) FIELD MONITORING				
	Activity 1.2.1b: Review of literature for glacier selection	Completed	15,806	15,045	95%
	Action 1.2.2.b: Selection of glaciers for field activities	Completed	13,172	12,538	95%
	Action 1.2.3.b: Planning of field missions on selected glaciers	Completed	35,827	34,353	96%
	Activity 1.2.4b: Field activities on selected glaciers (sampling and assessment of contaminants)	Completed	28,030	26,675	95%
	Activity 1.2.5b: Validation of acquired field data	Planned in 2023			
	Activity 1.2.6b: Elaboration of field data for each glacier	Planned in 2023			
	Activity 1.2.7b: Planning of field missions on selected glaciers	Planned in 2023			
	Activity 1.2.9b: Validation of acquired field data	Planned in 2023			
	Activity 1.2.10b: Data elaboration and sharing	Planned in 2023			
	Activity Result 1.3: Pakistan Glacier Inventory				

Indicator 1.3: Update the Pakistan Glacier Inventory *Target: Update Pakistan Glacier Inventory, Publication of 03 scientific research articles*	Activity 1.3.1: System requirements and work team definition	Completed	15,806	15,349	97%
	Activity 1.3.2: Implementation of the processing environment	Completed	12,961	12,934	100%
	Activity 1.3.3: Legend (Report identifying contents of Glacier Inventory Database)	Completed	5,269	5,362	102%
	Activity 1.3.4: Data acquisition	Completed	10,537	10,561	100%
	Activity 1.3.5: First classified map	Planned in 2023			
	Activity 1.3.6: Validation of the first map	Planned in 2023			
	Activity 1.3.7: Final classified map	Planned in 2023			
	Activity 1.3.8: Morphometric analysis	Planned in 2023			
Total			**202,002**	**197,177**	**98%**
EXPECTED OUTPUTS *And baseline, associated indicators and annual targets*	**PLANNED ACTIVITIES (as per AWP)**	**Activity Status** *Completed, Ongoing, Delayed, Cancelled*	**AWP Budget ($)**	**Expenditure ($)**	**% Delivery**
Output 2: Collaboration and sharing mechanisms among Pakistani and international institutions and students strengthened to build capacities for longer term glacier monitoring through innovative approaches and technologies					
Indicator: Web-based GIS climate and glaciers data archiving and sharing systems developed and maintained to enable knowledge and data sharing among responsible authorities, e.g. Met	**Activity 2.1: Implementation of the Information System**				
	Activity 2.1.1: System rwquirement analysis for the updating of the Geo App	Completed	54,162	53,560	99%
	Activity 2.1.2: New release of the GB GeoApp	Planned in 2023			

Deptt, Water Mgt. Deptt & EPA at GB and national level *Target: 01 number of systematic web-based GIS data archiving and sharing mechanisms exist*	Activity 2.1.3: Requirement analysis for new climate data and metadata publication	Planned in 2023			
	Activity 2.1.4: Updating of the SHARE Geonetwork Platform	Planned in 2023			
	Activity 2.1.5: Publication of the new web service with new high-altitude weather stations data	Planned in 2023			
	Activity Result 2.2: Capacity Building				
Indicator 2.2: Number of students and faculty members in the local universities trained in glacier inventory and monitoring *Target: 100 (end target with 40% female students' participation)*	Activity 2.2.1: Training strategy and logistic arrangements with local partners	Completed	38,778	35,992	93%
	Activity 2.2.2: Training for GEOMATICS	Completed	36,881	34,529	94%
	Activity 2.2.3: Training for glaciological field activities (2 trainings)	Completed	23,182	19,579	85%
	Activity 2.2.4: Training on avalanche risk	Completed	17,492	18,148	104%
	Activity 2.2.5: Local researchers for monitoring activities	Completed	10,537	10,619	101%
	Activity 2.2.6: Training for GEOMATICS	Planned in 2023			
	Activity 2.2.7: Preparation and publication of the book of the glacier inventory	Planned in 2023			
Total			**181,033**	**172,607**	**97%**
Monitoring and Evaluation *(Includes travel cost, end-term evaluation)*	Monitoring and Evalutaion		6322	4,724	74%

GMs (8%)		33,678	29748.31	88%
Quality Assurance and Oversight cost (DPC (CO quality review; Third-party financial spot-checks and audit fee)		31,612	0	0%
Total (USD)		**454,647**	**404,256**	**88.9%**