ICIMOD

Establishing Pir-Yakh Glacier as a benchmark glacier in Kabul basin, Afghanistan

November 2019

Executive summary

Strengthening Water Resources Management in Afghanistan (SWaRMA) is a two-year project supported by the Ministry of Energy and Water (MEW) – Government of Afghanistan and the Government of Australia, and implemented by the International Centre for Integrated Mountain Development (ICIMOD) and the Commonwealth Scientific and Research Organization (CSIRO). The project aims to strengthen water resource management in Afghanistan and implement a sustainable, long-term cryosphere monitoring programme in Afghanistan. This programme will evaluate available data on hydro-meteorological variables in catchments with snow and glacier.

MEW, with technical support from ICIMOD, installed the first-ever automatic weather station (AWS) at 4,528 masl near Pir-Yakh Glacier in Paryan District, Panjshir Province, Afghanistan, in August 2019. This station has the ability to capture eight meteorological parameters: precipitation, air temperature, relative humidity, solar radiation, barometric pressure, wind speed, wind direction, and gust speed. The AWS will improve understanding of meteorological parameters in relation to the¬¬ snow and ice melt runoff from the glacier.

A field expedition was organized by SWaRMA in August 2019 to install a hydro-met station consisting of one AWS, three rain gauge sensors and one pressure level sensor. The expedition team also conducted glacier mass balance analysis and stake network extension on Pir-Yakh Glacier. For accurate data collection on different elevation bands along the Upper Chomar valley up to the glacier, the team installed three rain gauge (RG3) and air temperature sensors. Data from these sensors will aid advanced modelling and water availability analysis of the catchment.

The pressure level sensor was installed near the glacier at 3,900 masl. This sensor records barometric pressure to compensate for changes in water level due to barometric fluctuations. The sensor was installed in a river channel to record the water level, which helps find the runoff originating from ice melt and snow melt.

Five stakes have been installed at Pir-Yakh Glacier's accumulation and oblation area. Depending on the issue being studied, these stakes, along with the AWS, are used to identify the water balance, discharge coefficient, surface and volume changes, glacier movement, glacier mass balance, and snow water equivalent. The lowest stake is at 4,400 masl and the highest at 4,880 masl, with each stake at a 100-m elevation difference.

Acknowledgments

This work to establish Pir-Yakh Glacier as a benchmark glacier is being undertaken by the Water Resources Department (WRD), MEW, in close collaboration with SWaRMA–ICIMOD, with support from the Government of Australia.

A series of trainings, on-the-job assignments, and guided sessions were organized by SWaRMA to establish the first-ever AWS at 4,528 masl near Pir-Yakh Glacier. We are confident that we can use this knowledge to conduct similar work and support MEW. We wish to express our sincere gratitude to Arun Bhakta Shrestha, Regional Programme Manager – River Basins and Cryosphere, ICIMOD, and Neera Shrestha Pradhan, Programme Coordinator – SWaRMA, ICIMOD. We also thank Anna Sinisalo, Sharad Joshi, and Tika Ram Gurung from ICIMOD for their technical support to establish this first glacier monitoring station in Afghanistan.

We would also like to express our sincere gratitude to Mohammad Tayib Bromand, who extended invaluable support as a focal person from MEW to SWaRMA. All members of the glacier monitoring team from WRD and ICIMOD who conducted this field visit put in immense work. We thank Kabul University experts for their participation in the trainings organized by SWaRMA and the field mission and for sharing their experiences. Paryan District's police personnel deserve a special mention for taking full responsibility of the team's security. We are grateful to Tamim Haqdad, Director of Panjshir River Basin, MEW, for his support throughout our field visit; Jawid Ahmad Ahmadi, ICIMOD, for logistical and field preparations; Ayub Khan Shinwari and Indu Chitrakar, SWaRMA–ICIMOD; and the local community of Paryan for supporting and working alongside the team and for their kind hospitality.

We sincerely thank the leadership and authorities from MEW for their kind support and advice: Hon. Gul Mohammad Khulmi, Acting Minister of Energy and Water; Hon. Khan Mohammad Takal, Deputy Minister of Water; Fazul Haq Bakhtary, former Director, WRD; and Fayezurahman Azizi, Director, WRD.

– Field expedition team

Introduction

The Hindu Kush mountains in Afghanistan reach an elevation of more than 7,000 masl in the east, where most of the glaciers are present. More than 3,000 small glaciers, which together cover 2,700 km^2, provide vital water resources to the region, especially for irrigation. The glaciers are concentrated in the highest parts of the three main drainage basins in the country: (1) the Afghan-Iranian plateau endorheic basin, (2) the Indus basin, and (3) the glacier-dominant Turkistan endorheic basin. Most glaciers in the north-facing slopes are shaded by mountain peaks, and those on the east and southeast slopes are shaded by monsoon clouds.

Study area

The Panjshir sub-basin is an important watershed of the Kabul River basin with a drainage area of 3,756 km^2. It is located towards the eastern part of Afghanistan. Surface and ground water flows for this sub-basin are mostly supplied by snow cover located at high altitudes (Figure 1). The upper portion of this sub-basin consists of steep mountain valleys in the Hindu Kush mountain range and remains snow covered throughout the year. The southern portion of the sub-basin (the right bank areas of the Ghorband and Panjshir rivers, near their confluence) opens into the broad and gentle-sloping fertile Shomali plain, an important irrigated stretch of land in the basin (World Bank, 2012).

In 2015, 69 glacial lakes were recorded (together covering 12.2 km^2). The sub-basin's ice reservoir volume is estimated to cover around 0.38 km^3. The glaciated areas are located between 3,912 masl and 5,254 masl, with the basin's highest and lowest elevations reaching 5,693 masl and 1,596 masl, respectively. The basin's waters are primarily from snow and glacial melt. Seasonal rainfall in the months of May and June makes the basin's rivers more flooded and causes rapid melting of the snow storage.

Pir-Yakh Glacier (35° 35' 50.49" N, 70° 10' 19.44" E) in Paryan District, Panjshir Province, Afghanistan, has been identified for glacial mass balance monitoring and automatic weather station (AWS) installation – one of the first glaciers selected for long-term mass balance monitoring in the country. Located 150 km north of Kabul, the glacier means "old ice" among local communities. Pir-Yakh is one of the biggest glaciers in Panjshir Province with an area of approximately 1.70 km^2. Its glacier tongue starts at 4,400 masl and accumulation zone peak ends at 5,070 masl (Figure 2).

FIGURE 1 MAP OF THE PANJSHIR SUB-BASIN

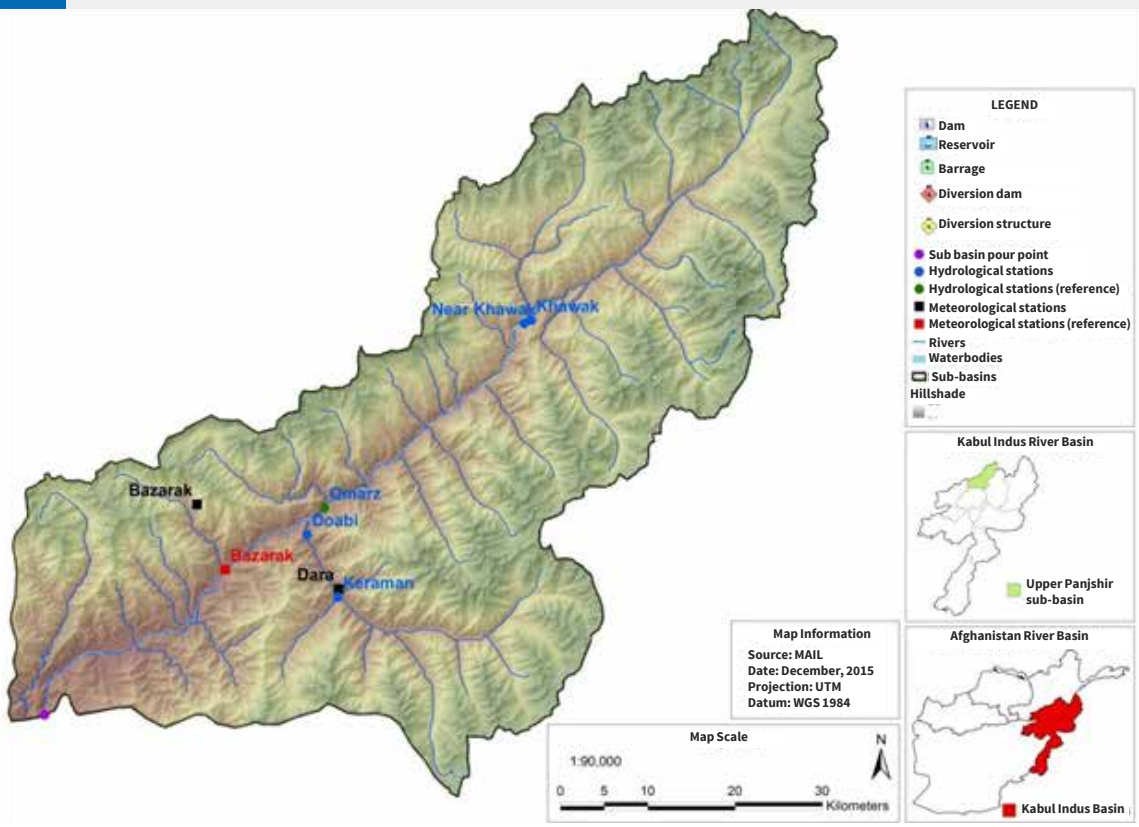
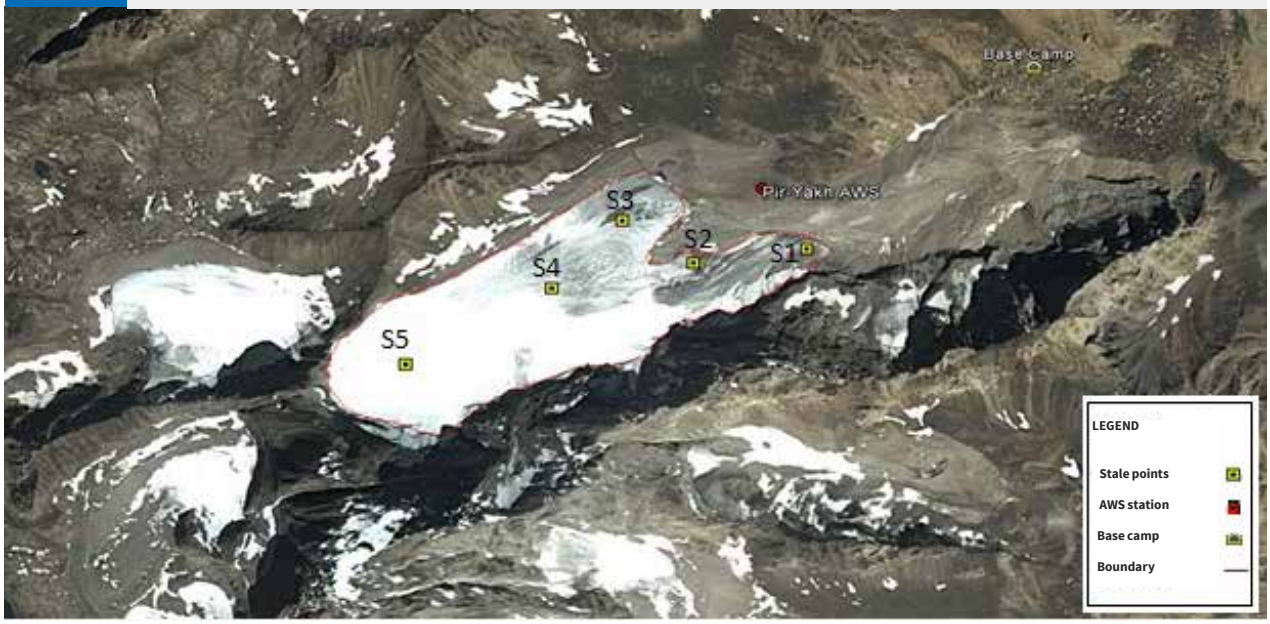


FIGURE 2 **STAKES INSTALLED IN PIR-YAKH GLACIER BY THE FIELD TEAM** (Source: Google Earth)



Objectives

The field expedition to Pir-Yakh Glacier in August 2019 had the following objectives:

Mass balance monitoring

- Maintain the stake network in the ablation and accumulation area
- Installation of new stakes
- Conduct snow accumulation measurements, including snow pit/core observations with density measurements

Hydro-met monitoring

- Install AWS on Pir-Yakh Glacier
- Install pressure level sensor (PLS) in the river
- Install precipitation and air temperature sensors along the valley
- Collecting data

Field route and schedule

Table 1 lists the resource persons involved in the expedition to Pir-Yakh Glacier. The journey began at 2,930 masl. Trekking started from a village called Lower Chumar – 16 km from the glacier base camp (4,140 masl). Two camps were set up on the path between the village and the base camp (Table 2), which is located near the glacier and the Mir Smir mountain range. The steep path extends through a V-shaped valley, continuing towards high mountains to the north.

TABLE 1 **RESOURCE PERSONS INVOLVED IN THE EXPEDITION TO PIR-YAKH GLACIER**

No.	Name	Affiliation	Designation
1	Milad Dildar	MEW/ICIMOD	Intern – Cryosphere/Glaciologist
2	Esmatullah Joya	MEW/ICIMOD	Research Assistant – GIS and Remote Sensing
3	Mahboobullah Bariz	MEW	Engineer, Flood and Drought Forecast
4	Hedayatullah Aryan	KU	Dean, Meteorological Department
5	Khan Agha Muzafari	MEW	Engineer, Snow and Glacier
6	Murtaza Rahimi	MEW/ICIMOD	Research Assistant – GIS and Remote Sensing
7	Abeer Ahmad	World Glacier Monitoring Service (WGMS)	National Correspondent in Afghanistan

TABLE 2 DAILY SCHEDULE OF THE FIELD EXPEDITION (6–14 AUGUST 2019)

Date	Day	Activity (M: morning, A: afternoon, E: evening)		Sleeping or max elevation (masl)
6 Aug 19	Tues	Kabul to Panjshir	M: Half-day trip (all members) A: Half day preparing	2,900
7 Aug 19	Wed	Trek 6 km to Camp 1	M: Trek (13:00–18:00); E: Camping	3,385
8 Aug 19	Thurs	Trek 4 km to Camp 2 Installation of three rain gauge (RG3) sensors and PLS	M: Packing and trek (08:00–10:00) A: Full-day work for installation E: Packing and camping	3,500
9 Aug 19	Fri	Trek 7 km to base camp Prepare site for installation AWS station	M: Packing and trek from 5 AM to 9 AM A: half day work and rest; E: camping	3,800
10 Aug 19	Sat	Stake installation on Pir-Yakh Glacier	M: Full-day work for installation E: Camping	4,700
11 Aug 19	Sun	Installation of AWS station	M: Full-day work; E: Camping	4,528
12 Aug 19	Mon	Trek downstream (4 km) Installation of RG2 sensor	M: Half-day trek with short breaks A: Installation of RG2 ; E: Packing and camping	2,900
13 Aug 19	Tues	Trek downstream (4 km) Installation of RG1 sensor	M: Half-day trek with short breaks A: Installation of RG1 E: Packing and camping	3,000
14 Aug 19	Thurs	Panjshir to Kabul	M: Full-day trip	

AWS installation

An AWS is the automated version of a traditional weather station. It consists of a weather-proof enclosure containing a data logger, rechargeable battery, telemetry (optional), and meteorological sensors along with an attached solar panel or wind turbine. It is mounted upon a mast.

The expedition team installed an AWS at 4,528 masl on Pir-Yakh Glacier (Table 3) – the highest-ever AWS in Afghanistan. It measures eight meteorological parameters: precipitation, air temperature, relative humidity, solar radiation, barometric pressure, wind speed, wind direction, and guest speed (Figure 3).

TABLE 3 AWS AND RG3 STATION LOCATION POINTS

No	Name of station	Elevation (m)	Latitude	Longitude	Installed date
1	Pir-Yakh (AWS)	4,528	35° 36.159’	70° 10.821’	26 Aug 19
2	RG2 sensor	3,242	35° 40.349’	70° 08.981’	27 Aug 19
3	RG3 sensor	3,698	35° 38.147’	70° 11.993’	27 Aug 19
4	RG4 sensor	3,902	35° 36.637’	70° 12.199’	27 Aug 19
5	PLS	3,904	35° 36.647’	70° 12.166’	27 Aug 19

FIGURE 3 AWS ON PIR-YAKH GLACIER AT 4,528 MASL

RG3 and AT-RH sensors

Three standard tipping-bucket rain gauges were installed to determine rainfall rates, times, and durations in the area. The rainfall will be measured with HOBO Pendant Event Data Loggers. Efficient at gathering and storing momentary contact events and temperature data, these sensors have been installed along the valley on different elevation bands to gather meteorological parameters: precipitation, air temperature, and relative humidity (Figure 4).

FIGURE 4 **INSTALLATION OF RG3 SENSORS**

Benchmark glacier and glacier mass balance measurements

Pir-Yakh Glacier is the first benchmark glacier selected for mass balance analysis in Afghanistan (Figure 5). Depending on the issue being studied, these stakes, along with the AWS, are used to identify the water balance, discharge coefficient, surface and volume changes, glacier movement, glacier mass balance, and snow water equivalent. The lowest stake is at 4,400 masl and the highest at 4,880 masl, with each stake at a 100-m elevation difference (Figure 6; Table 4).

TABLE 4 **LOCATIONS OF THE STAKES INSTALLED ON THE PIR-YAKH GLACIER**

No.	Name of stake	Elevation (masl)	Latitude	Longitude	Installed date
1	PY-10	4,500	35° 35.932’	70° 10.802’	25 Aug 19
2	PY-20	4,612	35° 35.850’	70° 10.670’	25 Aug 19
3	PY-30	4,694	35° 36.048’	70° 10.453’	25 Aug 19
4	PY-40	4,790	35° 35.873’	70° 10.163’	25 Aug 19
5	PY-50	4,879	35° 35.671’	70° 09.760’	25 Aug 19
6	Pir-Yakh (AWS)	4,528	35° 36.159’	70° 10.821’	26 Aug 19

FIGURE 5 STAKE LOCATIONS ON PIR-YAKH GLACIER (Source: Google Earth)

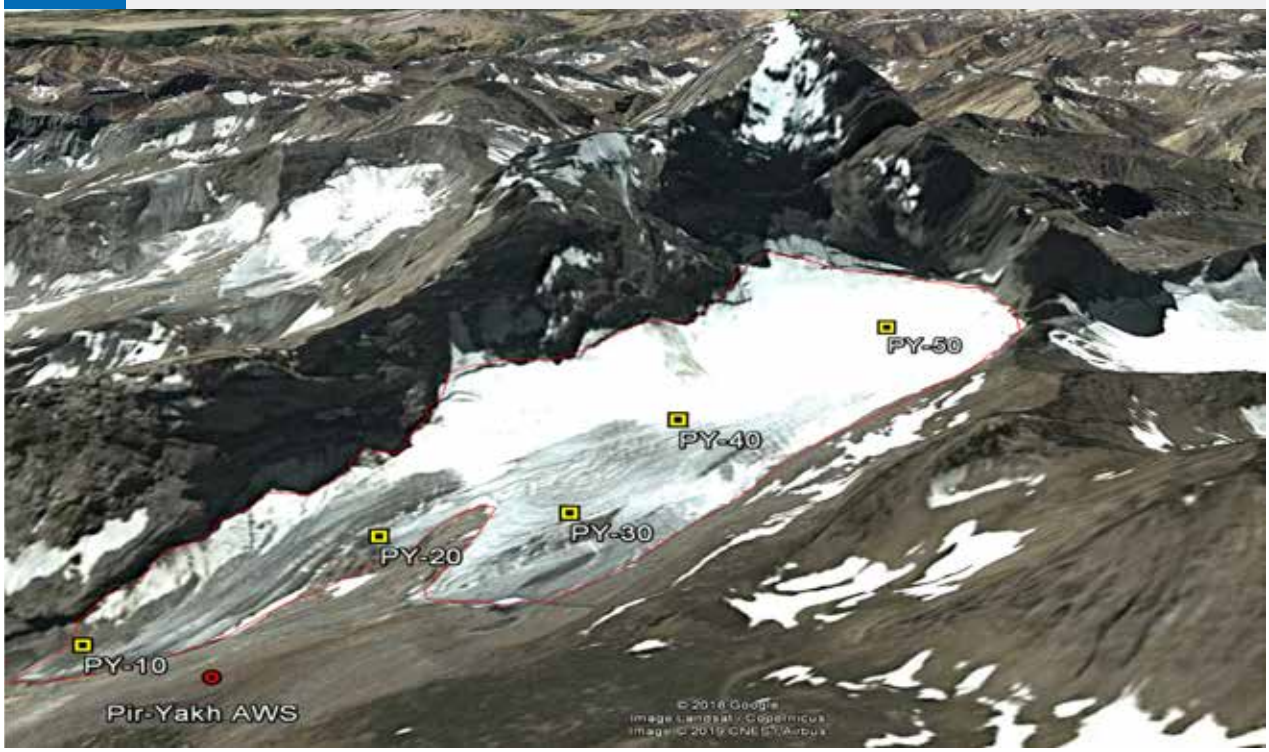


FIGURE 6 STAKE INSTALLATION ON ABLATION AND ACCUMULATION AREA AT PIR-YAKH GLACIER

PLS installation

PLS records barometric pressure to compensate for changes in water level due to barometric fluctuations. This sensor is installed on river channels to record the level of water and identify the runoff originating from ice and snow melt. The expedition team installed a 2 m iron safety slander to protect the sensor from sediment and high flows (Figure 7).

Snow accumulation measurements

Snow measurements were carried out on Pir-Yakh Glacier, including snow density measurement using snow pit/core, at 4,900 masl (Table 5; Figure 8).

FIGURE 7 PLS INSTALLATION IN A RIVER NEAR THE GLACIER

FIGURE 8 SNOW ACCUMULATION AND DENSITY MEASUREMENT USING SNOW PIT-CORE ON PIR-YAKH GLACIER

TABLE 5 SWE SUMMARY TABLE

GPS	ID	Longitude	Latitude	Elevation (masl)	slop	DP	Location name	SWE/mm
	1	**35° 35.671'**	**70° 09.760'**	**4,900**		**130 cm**	**Pir-Yakh**	55 cm = 310 mm
Depth (cm)	N	S	E	W	Average measurement points area			10 cm = 52 mm
1	130	132	135	131	2644/20 = 1.32 m			
2	132	132	135	131	Measurement number = 20			
3	132	130	132	133	Area = 1.32 m			
4	135	130	132	135	SWE = 646			
5	135	130	130	132	TSWE = 646*400 = 25840/1000 = 258 m^3			

Conclusion

An AWS was installed on Pir-Yakh Glacier at 4,528 masl for collecting accurate meteorological data for advanced glacier mass balance and modeling analysis. A PLS was installed in a river near the glacier at 3,900 masl. This sensor will provide data on the amount of runoff originating from the glacier melt, along with RG3 sensor (installed along the valley), which measures precipitation, air temperature, and humidity. Importantly, the benchmark glacier was identified and five stakes installed on the glacier from 4,400 masl to 4880 masl, each at a 100 m elevation difference. MEW is expected to continue the monitoring of this benchmark glacier on an annual basis with technical support from ICIMOD experts. The stations could also be installed on other glaciers in Afghanistan, depending on the availability of future funding.

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