

SNOW, RAIN, AND AN EARTHQUAKE: A MASSIVE AVALANCHE CYCLE IN TAJIKISTAN AND AFGHANISTAN

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ABSTRACT: In Central Asia avalanches primarily affect houses, villages, and valuable livestock versus recreational users. To protect lives and property, the Aga Khan Agency for Habitat (AKAH) developed an avalanche safety network for this region that includes avalanche forecasting, search and rescue teams, and community emergency response teams. This network was put to the test in February 2023.

A powerful winter storm hit Tajikistan and Afghanistan from 13-21 February 2023. Nine straight days of snowfall dropped over one meter in the valleys and double to triple that in the starting zones. The snow fell onto a depth-hoar dominated snowpack and triggered hundreds of slides. A mid-storm rain event triggered even more avalanches and flooded homes and villages. To make matters worse, on 16 February a 4.7 magnitude earthquake in northern Afghanistan likely triggered more slides. Snow, rain, and an earthquake coupled with a weak snowpack produced a historic avalanche cycle.

During the avalanche cycle, observers at 36 Weather Monitoring Posts (WMPs) recorded 593 avalanches. These WMPs are a cornerstone of AKAH's avalanche forecasting program. Every morning a person measures snowfall, snow depth, max and min temperatures, rainfall, and avalanche activity. The sites for these WMPs were specifically chosen because of the avalanche threat to the area. Villages surrounding these sites were trained in avalanche fundamentals and avalanche rescue.

The day before the storm I issued an *Avalanche Alert* for southern Tajikistan and northern Afghanistan while working as an avalanche forecaster for AKAH. They informed the public through in-person warnings, texts, social media, and mosques. They evacuated 1,024 households and several homes were subsequently destroyed by avalanches. Unfortunately, since many homes and villages are located in runout zones, loss of life was inevitable. Sadly, 38 people died, 35 were injured, 84 homes were destroyed or damaged (including a school), and 333 livestock were killed. However, these numbers were much lower than the 148 people who perished during a large avalanche cycle in this region in 2012. While any death is tragic, AKAH's avalanche safety network saved lives.

KEYWORDS: AKAH avalanche Tajikistan Afghanistan WMP

1. HISTORY

Avalanches kill hundreds of people every year in the Himalaya, Karakorum, Hindu Kush and Pamir mountains of Central Asia. Unlike recreationists, the victims in these regions rarely trigger the slides that kill them, nor do they have the option to avoid dangerous avalanche terrain. These are mountain communities threatened by large climax avalanches that run full track and devastate everything in their path. Deaths occur when these slides sweep through villages, destroying livelihoods, killing livestock, and wiping out homes, irrigation systems and fruit trees. The

people in these regions are born, live, and work in avalanche-prone terrain.

In 2012 an avalanche cycle in Tajikistan claimed the lives of 148 people. In 2014 an avalanche struck a village in the Wakhan Corridor of Afghanistan, killing 14 adults and eight children. A week later another slide devastated a remote village, taking nine lives and destroying many homes. This avalanche was 2 km wide, released 2,000 meters above the village and ran for 3 km. In 2015, in the wake of these tragedies, His Highness the Aga Khan IV tasked Aga Khan Agency for Habitat (AKAH) to stop avalanche deaths. The solution had to save lives, be simple to understand, and meaningful to local communities. It also needed to be cost-effective, sustainable, and applicable for a population that is often uneducated and illiterate.

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AKAH contacted me to help them build an avalanche safety network for Tajikistan, Afghanistan and Pakistan. This program would consist of four pillars:

1. Avalanche forecasting and education,
2. Gathering weather and avalanche occurrence data,
3. Creating search and rescue teams (SART), and
4. Training local avalanche preparedness teams (AVPT).

Furthermore, above all, it needed to be embraced by the communities.

A lack of weather and snowpack data made starting the program a challenge. We did not know if or how much it snowed in the mountains. Seeking a straightforward solution to measure snowfall, I wondered, "Couldn't we just give a guy a ruler?" The answer was yes. For about \$100 AKAH could establish a Weather Monitoring Post (WMP). A person in an avalanche prone village would collect weather data every morning and call it into a central office. The WMP consisted of a max/min thermometer, a 24-hour storm board, a seasonal snow stake, a handheld anemometer and a rain gauge. The WMP is fenced to keep children, goats and cows out. Every morning a person measures snowfall, snow depth, max and min temperatures, rainfall, and avalanche activity. Nearly a decade later, we now have 89 WMPs (15 in Afghanistan, 21 in Tajikistan and 53 in Pakistan). These Weather Monitoring Posts are managed by 150 trained volunteers—men and women—and are the cornerstone of the avalanche forecasting program.

Since 2017, daily data from all three countries get entered into a central database. This allows me to look at the daily weather log for all 89 villages and create an avalanche forecast, which by 2018, was issued weekly. With avalanche terrain identified, avalanche activity and WMP data reported, I give rudimentary forecasts from my home in Bozeman, MT, USA. Every morning, I skim the data and occasionally talk to AKAH staff to help them make decisions regarding avalanche warnings, education and evacuation plans. The weekly avalanche and weather forecast is updated frequently during storms. Since snowpack data is lacking, I lean heavily on terrain and weather for my forecasts, since I am only interested in the largest, most destructive natural avalanches. Furthermore, in the summer months I spend weeks training-the-trainers at AKAH, as well as giving local WMP operators basic education in data collection and avalanche awareness.

The avalanche program accomplishes five things:

1. Predicts avalanches and warns and informs the locals via cell or satellite phone, by Codan radio, or in the Jamatkhanas (mosques).
2. Trains the villagers to identify the common causes of avalanches and determine when the danger is increasing. We emphasize *Alert Thresholds* for snowfall, rain, and temperature so the locals can determine for themselves when warnings or evacuations are needed.
3. Collaborates with each community to create an evacuation plan by identifying safe areas inside the village or in the valley.
4. Establishes local AVPTs trained in avalanche rescue and creates professionally trained, country-wide SARTs.
5. And finally, having accomplished all this, the program earned the necessary buy-in from the local communities and blessings of the village elders.

2. SNOW, RAIN AND AN EARTHQUAKE... *What Could Possibly Go Wrong?*

On Sunday, 12 February 2023, I was alarmed by the precipitation amounts predicted by the Weather Research and Forecasting Model (WRF). The model predicted more than 1.5 m of snowfall for entire swaths of all three countries. In my ten years of experience with these models I had never seen anything like it. Meters of snow were predicted to fall in starting zones across Badakhshan, Afghanistan and GBOA, Tajikistan. Other weather models concurred and it was obvious the avalanche danger was going to rise quickly. AKAH is mostly concerned about full-track climax avalanches starting a thousand meters or more above the villages. The time-tested adage, "More snow equals more avalanches" was a certainty.

I put out an *Avalanche Alert* and it began snowing the next day. The Alert triggered a series of steps where AKAH AVPTs and SARTs and the Tajikistan government (CoES) informed the public by knocking door-to-door, sending text messages, posting on social media, and announcing in mosques.

For residents outside evacuation zones, the warning was simple: stay in place. Don't drive, don't walk between villages and don't wander outside to feed your animals. Households and villages in avalanche runout zones – with a total of 1,024 households – were evacuated. Since the average household in Afghanistan consists of 11 people and eight people in Tajikistan, thousands were evacuated. The number of avalanche deaths can be staggering from

an avalanche cycle since a single home can have casualties in the double digits.

It snowed for nine days, totaling about one meter in the valleys and triple or more in the starting zones. We know this because WMPs measured valley snowfall and 3-meter-tall snow masts placed in the starting zones were buried. The snow fell onto an intermountain snowpack that was likely undermined by a thick layer of depth hoar that formed after an early season snowfall, cold temperatures and a relatively dry December. Before this avalanche cycle, slides were releasing at the ground in January, indicating an unstable basal layer.

All told, 593 avalanches were reported by the WMPs during this cycle. These represent only slides that were seen along roads and villages. Obviously, countless more occurred that were unreported.

Snowfall began on the 13th and by the 14th the avalanches started to run in both Afghanistan and Tajikistan. One slide hit a bus carrying 14 people without casualty and another hit a fuel truck which pushed it into a river, killing the driver and passenger. By the end of the day another two slides had killed five people. On the 15th, several families were buried in 10 homes struck by slides. AVPT and SART responded and saved the life of a little girl with CPR. On the 16th a 4.7 magnitude earthquake hit northern Afghanistan, a geologically active area at the intersection of the Karakorum, Hindu Kush and Pamir mountains. It occurred in the evening and damaged 80 homes. The epicenter was located in the midst of all the avalanche activity and likely triggered even more avalanches. To make matters worse, on the same day, heavy rain fell at lower elevations measuring 7.5 cm of water over two days. This resulted in widespread avalanches being triggered at low elevations and flooding in villages, which hampered rescue efforts as the roads were washed out. The local volunteer AVPT had their hands full, rescuing people buried in their homes and clearing roads for vehicles. Another five people were dug out and saved by CPR, an astonishing success.

We do not know which avalanches were triggered by snow, rain or the earthquake, but we can tally the loss of life and destruction:

- Thirty-eight people died and 35 were injured.
- 333 livestock were killed, which is where the wealth and savings of the villagers reside.
- Eighty-four homes and one school were destroyed or damaged.

Amid this natural disaster there were success stories, which can be attributed to the avalanche safety network and the efforts of trained locals:

- Six people, including a young girl, were resuscitated by CPR.
- Rescuers pulled a father and his two children out of their buried home alive.
- Five homes were destroyed immediately after AKAH teams evacuated their residents.
- In response to this avalanche cycle, AKAH-Afghanistan provided food to 27,437 families (more than 190,000 people) and funds for food, winter clothing, blankets, heating, and fuel to 3,295 families (almost 23,000 people).

3. FUTURE

Accurate forecasting of avalanches requires studying terrain, weather and snowpack. In Central Asia the avalanche terrain is mapped, and we have daily weather observations and weather models, but we do not have snowpack data. Last year, meteorologist Dr. John Snook applied the Swiss SNOWPACK model in order to help visualize the snowpack structure in the forecast area. AKAH also has plans to use snow probes to gather data on the snowpack layering on a trial basis this coming winter. There is also value in installing strategically placed remote weather stations. However, besides the high cost and regular maintenance, government restrictions on sharing weather data create obstacles.

4. CONCLUSION

The avalanche program was put to the test and performed successfully. Avalanche forecasting, avalanche alerts and warnings, trained AKAH staff, Tajikistan CoES and community volunteers worked to warn, inform, and evacuate the population of remote regions. In 2012 a smaller avalanche cycle with a shorter duration killed 148 people in Tajikistan. This storm claimed the lives of 38 who died in a much bigger and more consequential avalanche cycle, proving that alerts, evacuation, training and forecasting help keep casualties low.

Simplicity is the secret to AKAH's success. Basic tools like rulers and thermometers are sufficient. Observations from the villagers at risk are invaluable. They have a deep history and understanding of the natural disasters in their regions. Avalanches are just one of many. They must contend with floods, rockfalls, landslides, earthquakes, and glacial lake outbursts. They understand their surroundings and are keen to learn and become self-sufficient. Expensive, remote weather stations, helicopters, and teams of professional forecasters working in the highest mountains in the world are not practical, efficient, or possible. Simplicity wins. It's cheap and reliable. A person walking outside to measure snowfall and writing it in a notebook does not have to

contend with power, communication or instrument failure. While forecasting for winter recreationists requires a deep understanding of the snowpack structure to warn about human-triggered avalanches, in Central Asia climax avalanches are our primary concern and are typically triggered by big snowstorms or rain.

In 2021, a month before the Taliban took over Afghanistan, I was lamenting with a villager that the forecasting program might end with their rule. He said, "Sir, it will be ok. You taught us what to look for, to measure the snow, to know when to evacuate. We will be fine." He was right.

ACKNOWLEDGEMENT

I wish to acknowledge His Highness, Aga Khan IV for his vision and support of the avalanche program. AKAH co-workers Shodmon Hojibekov, John St. Stanley, Deo Raj Gurung, and outside experts John Snook, Ron Simenhois and Karl Birkeland.

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