

Glacial Water and Spring-shed Management in High Altitude Himalayas

In cooperation with

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DEUTSCHE ZUSAMMENARBEIT

Implemented by
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ACRES OF ICE

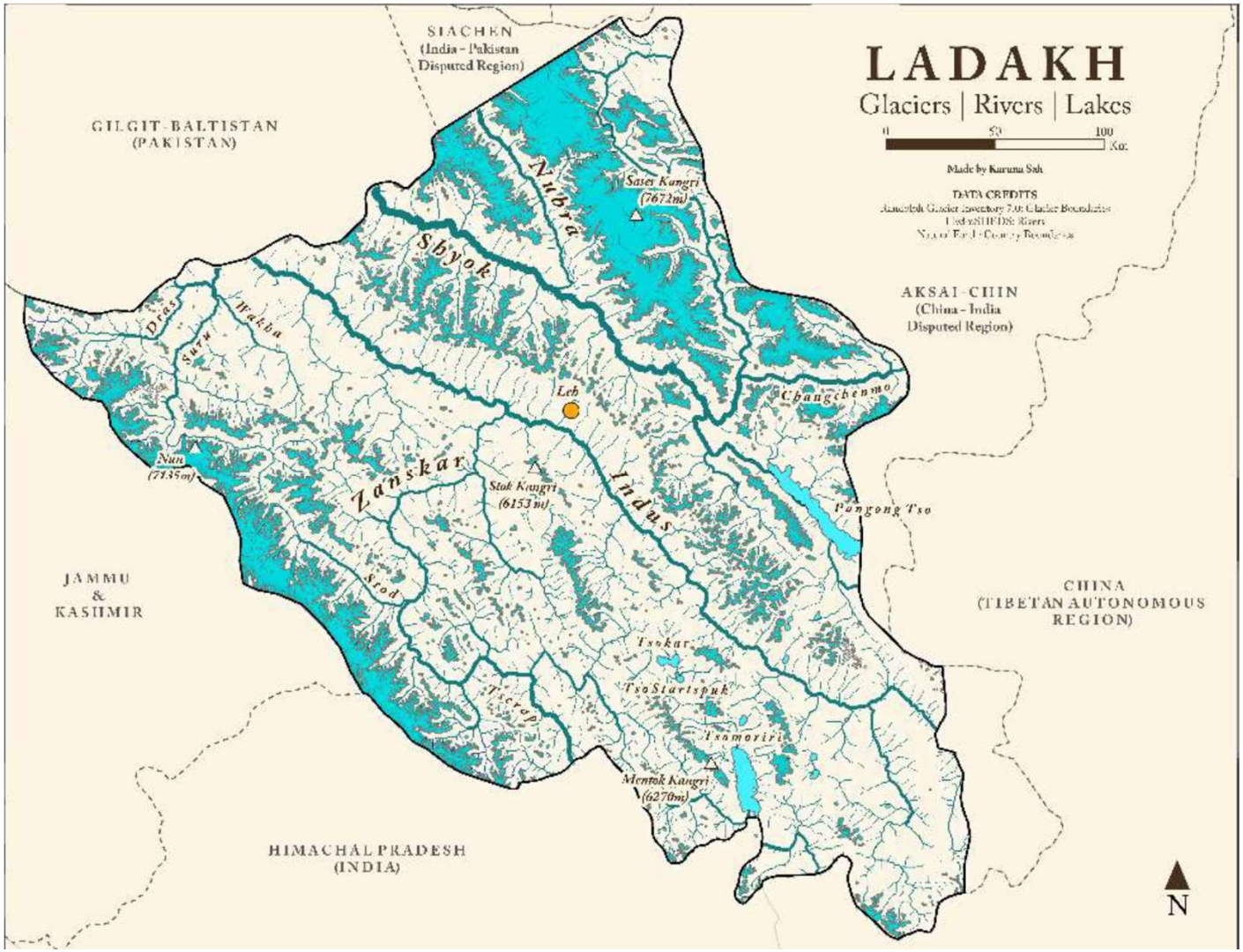
सत्यमेव जयते
Ministry of Rural Development
Government of India

सत्यमेव जयते
Ministry of Jal Shakti
Government of India

Introduction

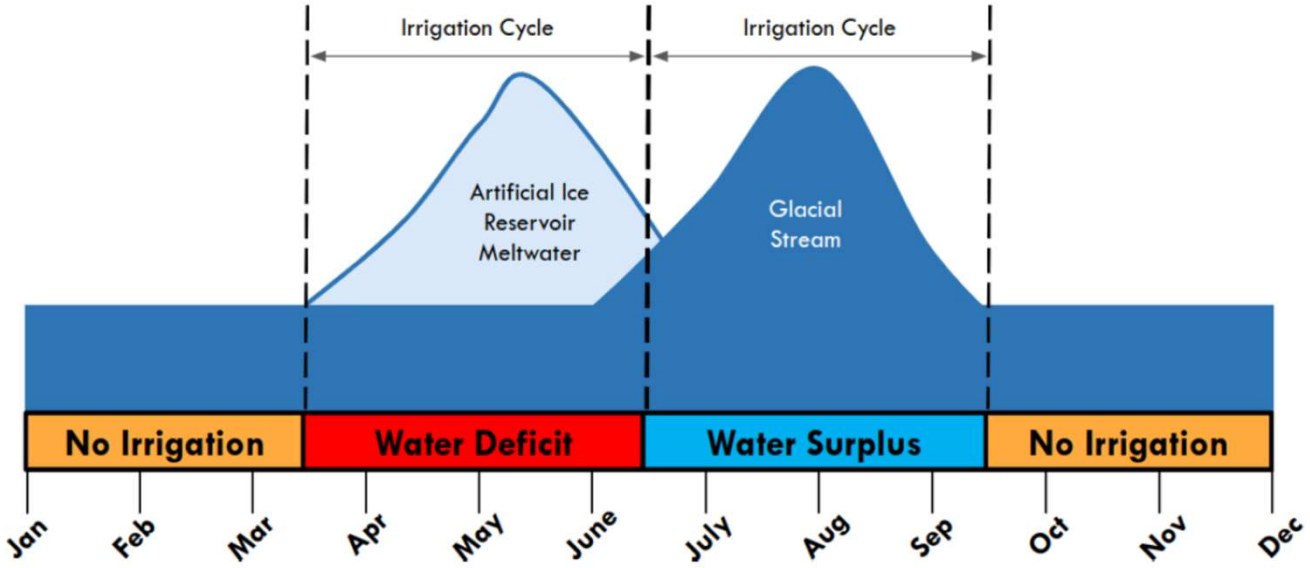
- High-altitude communities from the Himalayas face challenges: **retreating glaciers, shifting precipitation patterns,** and misalignment between water availability and agricultural needs.
- This is compounded by the fact that **90% of villages in Ladakh depend on glacial water** supply, making them particularly vulnerable to changes in the cryosphere.
- It is estimated that **10% of Ladakh's villages may face abandonment by 2050** due to insufficient water during the summer months (April to October) for irrigation and daily use.
- The **Automated Ice Reservoir (AIR) Initiative** in Ladakh represents a significant advancement in this global movement, combining traditional knowledge with modern technology to create climate-resilient water solutions.
- The idea of building **Artificial Glaciers (AGs)** was developed and experimented with in the RDD in 1987 at Shara and Mudh villages. **Mr Chhewang Norphel** furthered this idea in the 1990s and built AGs in more villages under the Watershed Development Programme (WDP).
- This presentation introduces **automation,** aiming to improve upon **traditional methods** and enhance scalability, ice volume, and community benefit.
- This initiative is implemented by **Acres of Ice** in collaboration with **I&FC, GIZ, MCV and NABARD.**

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LADAKH
Glaciers | Rivers | Lakes
0
50
100
Km
Made by Karuna Sah
DATA CREDITS
SIACHEN
(India - Pakistan
Disputed Region)
GILGIT-BALTISTAN
(PAKISTAN)
AKSAI-CHIN
(China - India
Disputed Region)
JAMMU
&
KASHMIR
HIMACHAL PRADESH
(INDIA)
CHINA
(TIBETAN AUTONOMOUS
REGION)
Nubra
Shyok
Suru
Wakha
Leh
Changchenmo
Zanskar
Indus
Stok Kangri
(6153m)
Pangong Tso
Tsokar
Tso Startsapuk
Tsomoriri
Mentok Kangri
(6270m)
Saser Kangri
(7672m)
Nun
(7135m)
Srod
N

Technical Feasibility Assessment

- **Mobile Connectivity:** Essential for remote monitoring and SMS-based system control
- **Road Accessibility:** Important for maintenance and emergency interventions
- **Water Source Temperature and quantity:** Critical for determining risk of pipeline freezing events. Sites with winter water temperatures below 1 C or discharge rates below 1.5 litres per second were rejected.
- **Weather Conditions:** Selected locations where winter temperatures remain below -5°C for at least a month
- **Terrain Features:** Valley slope, width, soil stability, presence of natural obstacles, and other geographical factors affecting system installation and performance



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AIR Architecture

Intelligent Decision Framework:
The system continuously monitors critical weather (W) parameters i.e. air temperature, humidity and wind speed along with critical pipeline (P) parameters namely pressure and water temperature. The system intelligently shifts between **spray and drain modes** to avoid **pipeline freezing** events while maximizing freezing rates.

Integrated Control Architecture
The Sensor Conductor PCB functions as the system's brain, processing all sensor inputs through custom algorithms to determine optimal operating states. Valve Node PCBs receive wireless commands from the sensor conductor and precisely control the mechanical valves that regulate **fountain discharge rate.**

Water Source Integration
The system taps into either **spring or glacial water sources**, water is extracted through carefully routed pipelines designed to work with the natural topography.

Optimized Fountain Design
Custom 3D-printed fountains designed through extensive testing and engineered to account for the complex relationship between water droplet size, trajectory, and freezing conditions. **Fountain designs vary based on water availability and desired ice formation patterns.**

How are Ice reservoirs built?

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Step 1

Pipeline connects the ice reservoir to a source on higher ground, drawing water downhill.

Step 2

A fountain system sprays freezes water on a domed structure.

Step 3

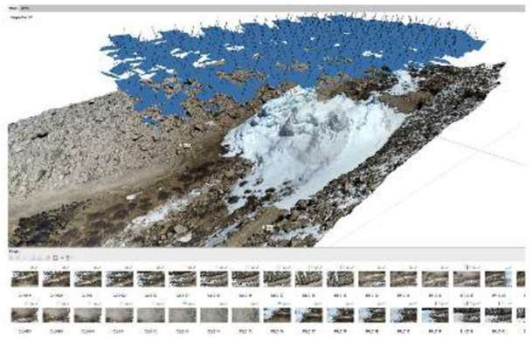
As ice accumulates, more piping can be added to increase the height of the structure.

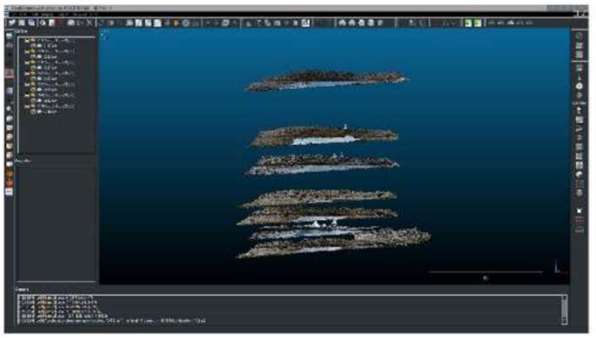
Step 4

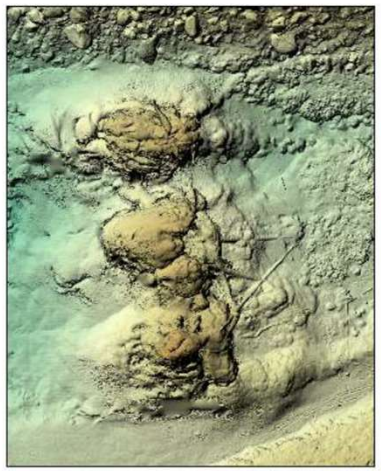
Irrigation systems distribute their meltwater.



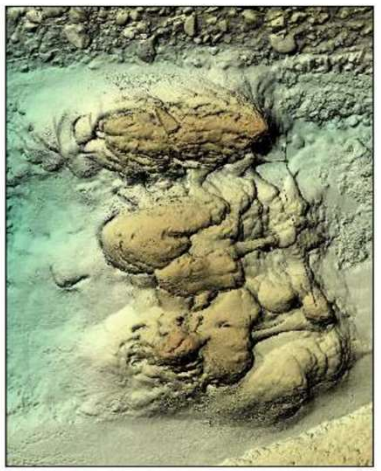
Drone based monitoring and performance analysis







Jan 2025



Feb 2025

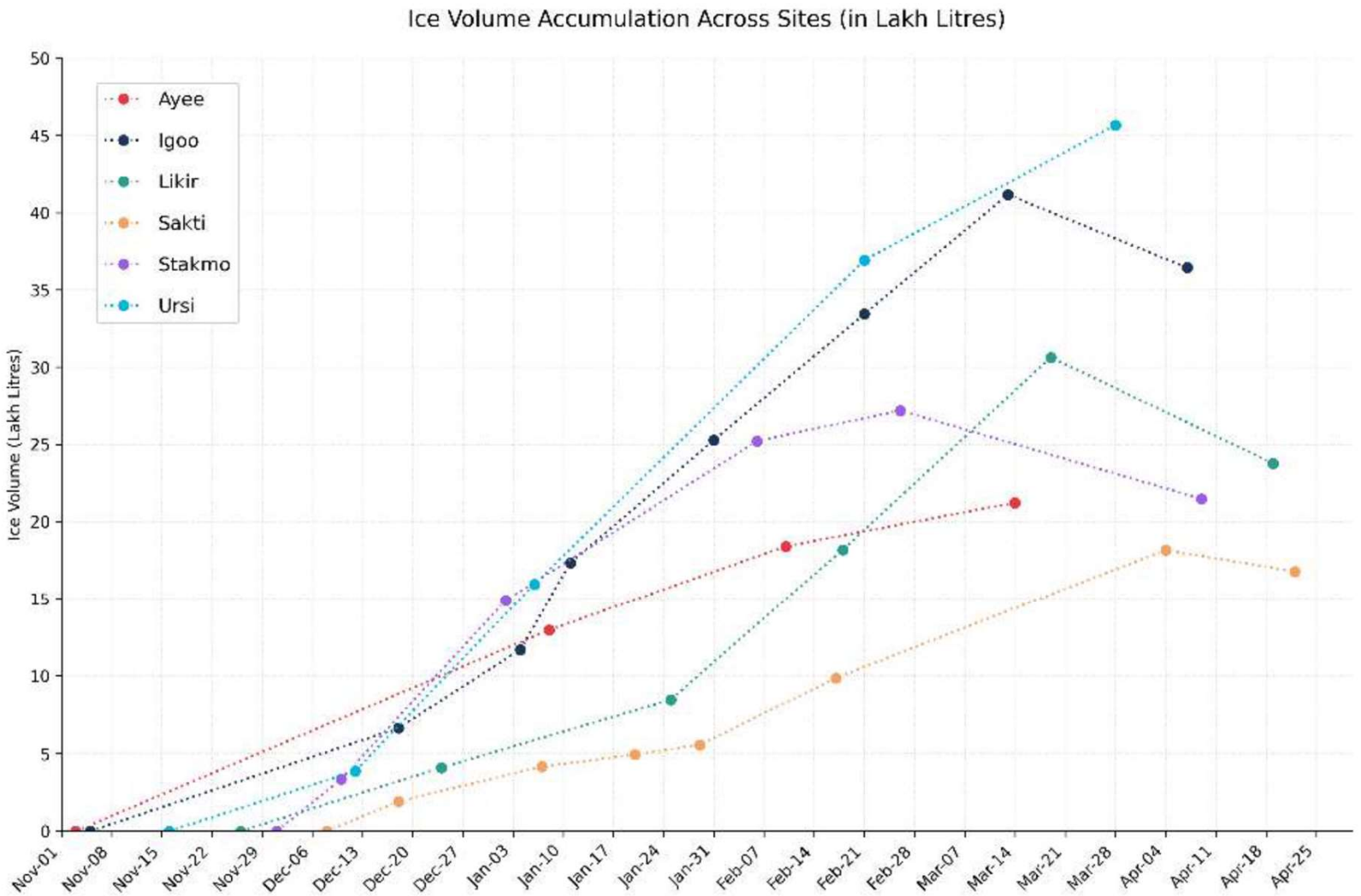


Ice addition between
Jan and Feb

Case Example: Igoo Village

- The automated system in Igoo demonstrated exceptional performance, achieving a maximum ice volume of 41 lakh litres by March 13, 2025.
- According to the site data, Igoo experienced mean air temperatures of -8°C (with minimums reaching -20°C), ideal water temperatures averaging 4°C, and discharge rates averaging 3.5 liters per second – all contributing to the exceptional ice formation results.
- This meant that spray decisions were primarily constrained by weather conditions alone. Therefore, the automation system kept the fountain spraying for around 90 % of the time until March 2025.
- Notably, we recorded no pipeline freezing events in Igoo throughout the entire season, which contributed significantly to the continuous and reliable operation of the system.




Ice Volume Accumulation Across Sites (in Lakh Litres)
Ice Volume (Lakh Litres)
Ayee
Igoo
Likir
Sakti
Stakmo
Ursi
0
5
10
15
20
25
30
35
40
45
50
Nov-01
Nov-08
Nov-15
Nov-22
Nov-29
Dec-06
Dec-13
Dec-20
Dec-27
Jan-03
Jan-10
Jan-17
Jan-24
Jan-31
Feb-07
Feb-14
Feb-21
Feb-28
Mar-07
Mar-14
Mar-21
Mar-28
Apr-04
Apr-11
Apr-18
Apr-25

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Key Takeaways and Way Ahead

- The AIR initiative has successfully demonstrated the effectiveness of automated ice reservoirs in **addressing seasonal water scarcity** across diverse villages in Ladakh.
- The implementation achieved a total **ice volume of 184 lakh litres**.
- The automation system proved particularly valuable in preventing **pipeline freezing** events in most locations.
- The cost analysis demonstrates the economic viability of the AIR approach, with **a three-year cost efficiency of INR 0.23 per liter** (23 paisa per liter).
- Seven out of eight households of Ursi acknowledged **higher agricultural income and water availability** from ice reservoirs.
- As climate change accelerates **glacial retreat in mountain regions**, the AIR approach offers a **scalable, cost-effective solution** that combines indigenous knowledge with modern automation.


IMPACT & SCALE
12
AIRs deployed
14 M
total addressable market across HKH, Andes & alps
50M
water stored as Ice addressing 600 + HH
$0.003
per litre cost achieved. 55x cheaper than alternates
3 sites
ready for deployement in Kyrgyz & Nepal
~ 10%
increase in revenue reported across villages

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