Glacier Lake Outburst Floods (GLOFs) Mitigation

- The Missions of Snrkhsn is to establish an efficient and effective ecosystem for GLOFs Mitigation and reliable Early Warning systems at any part of the planet. Before diving into the much required technical and other perspectives, we would start a brief but comprehensive study of whole GLOF problem backed by much famous standards, perceptions about GLOFs Mitigation solutions by CDAC affiliated authors, researchers, and Geospatial experts: -

Glacier Lake Outburst Floods could be triggered by various seismic events, natural disturbances and other factors which are out of human control but at the most principal level it is just because an ice wall or moraine dam broke out causing millions of litres of water to release in a fraction of time.

a) Causes for Moraine collapse and Technical Perspectives along with strengths and drawbacks:

Collapse Scenarios:

1)An avalanche or an earthquake caused the moraine dam to break out.

2)A high level of amount of water flow caused a pressure on moraine dam causing it broke out.

3)Weakening of wall over time collapsed the dam.

So, in Conclusion, for all GLOFs Mitigation measures we are on a mercy of Moraine Condition or wall holding the passage to all Glacier lakes. The biggest issue is that the collapse could be so unpredictable leaving no time to respond. However, using some attributes, we can safely predict and estimate the moraine condition. Some triggers could be:

1)Water level -Water level over some is the biggest threat.

2)Nature of wall. -Constitutes of what material is wall made up of.

3)Temperature. And Humidity – Rise and fall in daily or average temperature could cause melt, refroze thus causing changes in overall conditions of that Glacier Lake.

4)Ice condition -The nature of soil whether it is fresh,old,fine,Schematic.

5)Degradation of layers in wall or moraine dam -The degradation of layers, materials in moraine dam upon a period could play a vital role.

6)Fragmentation of glaciers -The nature of glaciers and centuries old topography how they formed could help understand more about GLOFs and geological conditions of that area.

7)Stranded Ice Block or floating pieces of ice could breach the wall causing an unpredictable GLOFs.

Thus, in conclusion, all the GLOFs Mitigation measures lies around how better and well we understood the conditions of wall or dams of that Glaciers areas along with nearby Topography.

So, let's move ahead to our solutions, but before moving to the technical perspective of our solution, we need to understand that a solution has to be practical, feasible and possible involvement of all the stakeholders.

Let's start from a basic analysis of any possible solutions in way of finding the most optimal one:

1)To Find the best solution we must satisfy all the possible triggers for moraine we could, which are mentioned above:

Environment conditions like temperature and humidity could be easily measured through user level sensors making it affordable and efficient.

The most important part is the mapping of Glacier Lake, we will use LiDAR based technology coupled with high-definition cameras over Radar based or other forms because of accuracy, penetration, and reliability.

Approach 1: Terrestrial Based Modules.

Terrestrial based Modules constituents of such above mentioned sensors placed in different sections of the Lake could provide a whole 3D mapping with real time data of Glacier Lake making it most reliable for throughout the data.

Problem: -We must install multiple sensors for one lake crossing the budget constraints and moreover terrestrial based LiDAR may not be able to give us the Mapping of Such walls and dams under the water.

Approach 2: Aerial Born Mapping

Aerial Born Mapping with sensors and LiDAR installed on drones satisfy the drawbacks of conventional mapping techniques, making it cheaper and efficient to map large areas.

Problems: -Low Flight times, Human intervention requirements, Unavailability during harsh climates, high logistics costs and regular field visits to be made by humans for field data will be make it risky during GLOFs.

The other solution could also be solely satelliting based mapping, but factors like unavailability of ground truth data and much expensive Satellite spectrums for such high-definition mapping.

What's the optimal solution then?

Snrkshn call for a Hybrid ecosystem of best of the aerial and terrestrial data coupled with satellite if required.

Demand of Problem:

The changes in Moraine and Glacier Lakes happen on daily, weekly basis so we need periodic data rather than solely real time data so to low expenses and lowest possible human assistance near GLOFs.

Aerial borne mapping with 3D and bathymetric LiDAR will be the most efficient and optimal solution covering a large area with one single unit and as far to overcome the challenge of human intervention and reliable data we could integrate a single IOT module with ground sensors like Temp, Humidity, Cameras and most importantly which will act as docking station for this autonomous drone equipped with high definition cameras and LiDAR(as mentioned above).Thus Drone will act as a Mapping instrument which could be controlled remotely from servers.

How this will work

The Docking station will have all non-mapping sensors, wireless charging docking system and a secondary camera, power, communication modules (could be satellite if budget allows or a radio module connected to base station some kilometres away to relay data).

Drone will have cameras, LiDAR and other sensors and will communicate only to docking station and to relay all the data. The autonomous drone will use same LiDAR to save costs and instruction could be stored into it during docking and will return to docking.

Thus, this approach could solve the problem of reliable, accurate data while keeping budget and expenses in mind.

The timeline of whole Solution (Snrkshn):-

Satellite data could be open source or could be like this from ISRO data

https://www.isro.gov.in/Satellite_Insights_Expanding_Glacial_Lakes_Indian_Himalayas.html#:~:text=Specifically%2C%20130%20of%20these%20lakes,and%20Brahmaputra%20River%20basins%2C%20respectively.

will be used for primary research, team will visit the field and will do a field research to deploy Docking module and Drone.

Docking station will store the data from Non-mapping sensors and will relay in every 30 Minutes and instruction could be send to drone (pre stored maps of the area with points) to relay data and do a mapping to get the real time data of Moraine walls and Glacier Lakes new Changes in Topography or even during GLOFs Docking station will relay the data and then Geo experts at any part of the world while using advance ML techniques could predict the Moraine years back thus just one unit could serve whole area.

Moreover, this ecosystem could integrate SOS or nearby villages, government agencies,3D mapping of how much water required to predict the breaking of wall,

Another suggestion from AI expert's systems regarding to control or how to reduce the level of water.

At the Conclusion, the data collection is just one part, the major powerhouse lies in harnessing the power of mapping and doing advance ML on that data and predicting the

areas, even timeline of that GLOFs along with the involvement of all stakeholders and implement the measures to reduce the risks.