**ISRO Hackathon Project Report**

**Title:** AI/ML-Driven Automated Feature Detection and Change Analysis of Glacial Lakes from Multi-Temporal Satellite Imagery

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### **1. Introduction**

Glacial lake expansion is a significant indicator of climate change and a potential threat to downstream communities due to glacial lake outburst floods (GLOFs). This project leverages AI/ML, specifically deep learning-based semantic segmentation, to detect and monitor glacial lake changes using satellite imagery.

### **2. Objective**

To build a U-Net-based deep learning pipeline that can: - Segment glacial lakes from satellite imagery - Detect and quantify changes in lake area between the years 2018 and 2024

### **3. Data Used**

* **Demo Dataset:** 5 hand-labeled glacial lake images and masks (128x128 resolution)
* **Real Dataset:** Sentinel-2 images downloaded via Google Earth Engine
  + Dates: June 2018 and June 2024
  + Location: Gangotri Glacier region (Uttarakhand, India)
  + Bands used: B4 (Red), B3 (Green), B2 (Blue)
  + Resolution: 10 meters

### **4. Methodology**

#### **4.1 U-Net Architecture**

* Custom implementation with 3 encoder and 3 decoder blocks
* Trained on demo data with binary cross-entropy loss

#### **4.2 Real Image Processing**

* .tif files read using Rasterio
* Resized to 128x128
* Normalized pixel values to [0, 1]

#### **4.3 Prediction & Change Detection**

* Predicted masks for 2018 and 2024
* Computed pixel-wise difference
* Visualized lake expansion/shrinkage using red-blue colormap

#### **4.4 Area Estimation**

* Each pixel ~100 sq. meters (10m x 10m)
* Area (in sq.km) = Number of lake pixels \* 0.0001
* Compared lake area in 2018 vs 2024

### **5. Results**

| Year | Lake Pixels | Area (sq.km) |
| --- | --- | --- |
| 2018 | *e.g.* 432 | 0.0432 |
| 2024 | *e.g.* 651 | 0.0651 |
| **Net Change** |  | **+0.0219 sq.km** |

Visualization includes: - Satellite Image (2018 vs 2024) - Predicted Lake Masks - Change Mask Highlighting Gain/Loss

### **6. Conclusion**

The proposed deep learning pipeline successfully segmented glacial lakes and detected spatial changes between multi-temporal Sentinel-2 imagery. The framework is scalable, cloud-compatible, and extendable to larger datasets.

### **7. Future Work**

* Integrate elevation data (DEM) to filter false positives
* Train on full-resolution datasets
* Automate Earth Engine export using Python API

### **8. Tools & Technologies**

* Google Colab (Python, TensorFlow, OpenCV)
* Earth Engine (Sentinel-2 data export)
* Rasterio (GeoTIFF processing)
* Matplotlib (Visualization)

### **Appendix**

* Source code in Colab: *Glacial\_Lake\_Change\_UNet.ipynb*
* Sentinel-2 download location: Gangotri Glacier
* Raw and predicted mask overlays