LANDSLIDE DETECTION USING SATELLITE IMAGERY

By

Avishek Mondal - 679

Tamal Mallik - 759

Souvik Baidya - 748

UNDERSTANDING LANDSLIDES: A GLOBAL CONCERN

- **What Are Landslides?**

  Definition: Landslides are the movement of rock, earth, or debris down a slope due to gravity.

  Types: They can occur as rockfalls, deep failure of slopes, and shallow debris flows.

- **Recent Devastating Events**

  Kinnaur, India (August 2021): resulted in at least 13 fatalities.

  Maharashtra, India: Monsoon-triggered landslides led to over **136 deaths**

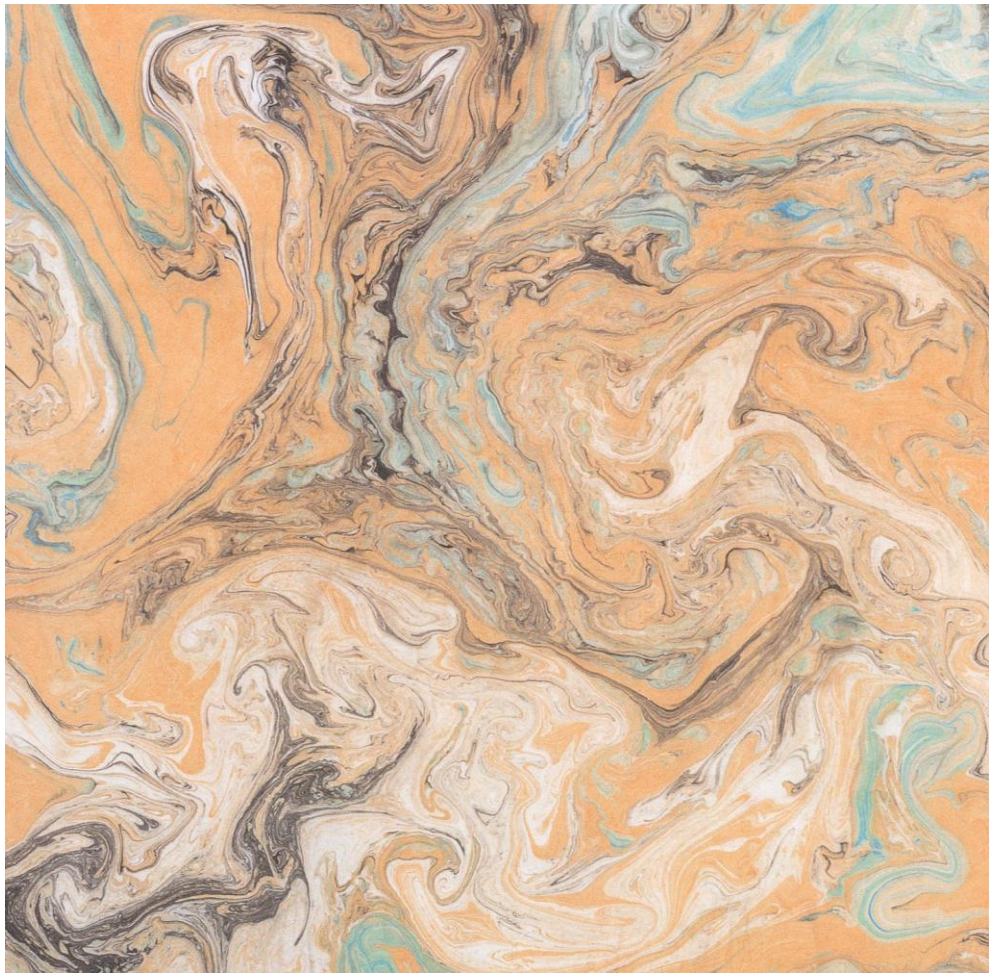
- **Global Impact**

  Statistics: Between 1998 and 2017, landslides affected **4.8 million** people caused over 18,000 fatalities worldwide.

  Frequency: On average, thousands of deaths are attributed to landslides each year.

OBJECTIVE:

- Preprocess Satellite image
- Extract Features from image
- Training Machine Learning model based on given data
- Give new Data to recognize if the area prone to landslide or not

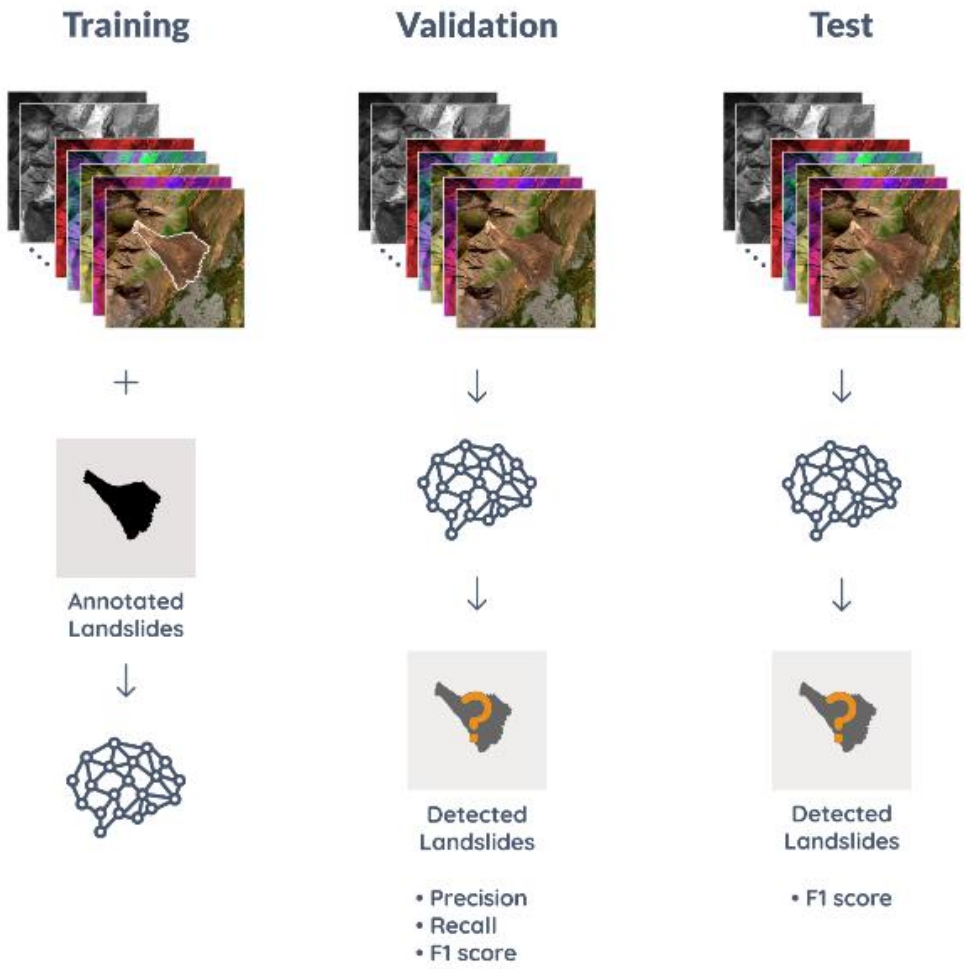


DATASET

- **Landslide4Sense** dataset has three splits
    - Training **3799**
    - Validation **245**
    - Test **800**

Each image patch is a composite of 14 bands that include:

- **Multispectral data**
- **Slope data**
- **Digital elevation model (DEM)**



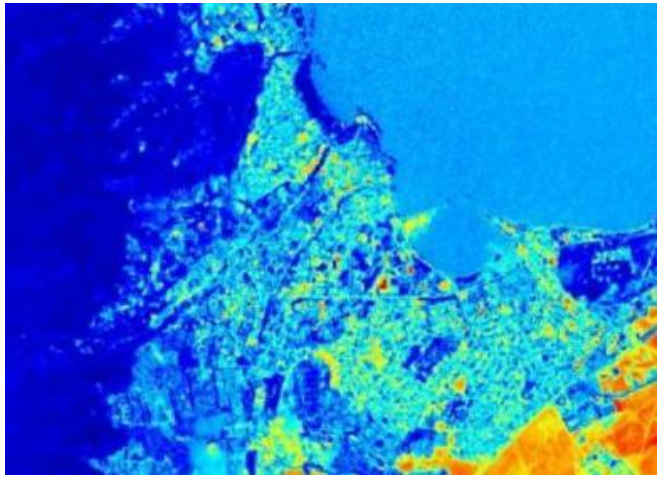
- **Multispectral data from Sentinel-2: B1, B2, B3, B4, B5, B6, B7, B8, B9, B10, B11, B12**

MULTISPECTRAL DATA

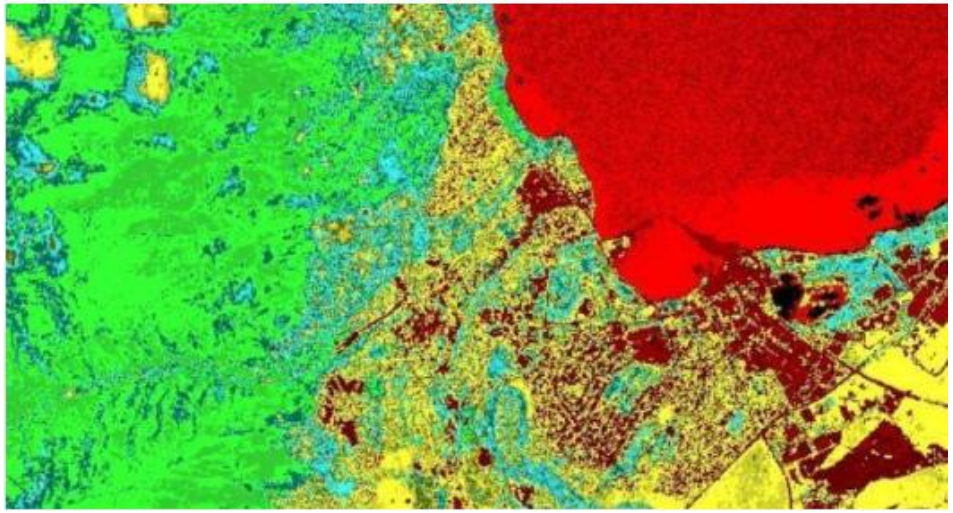
- **B1**: Coastal Aerosol, Ultra Blue, 443 nm[1].
- **B2**: Blue, Blue, 490 nm[1].
- **B3**: Green, Green, 560 nm[1].
- **B4**: Red, Red, 665 nm[1].
- **B5**: Vegetation Red Edge, VNIR, 705 nm[1].
- **B6**: Vegetation Red Edge, VNIR, 740 nm[1].
- **B7**: Vegetation Red Edge, VNIR, 783 nm[1].
- **B8**: NIR, NIR, 842 nm[1].
- **B8a**: Narrow NIR, VNIR, 865 nm[1].
- **B9**: Water Vapor, SWIR, 940 nm[1].
- **B10**: Cirrus, SWIR, 1375 nm[1].
- **B11**: SWIR, SWIR, 1610 nm[1].
- **B12**: SWIR, SWIR, 2190 nm[1].

Natural Color (B4, B3, B2)

Short-Wave Infrared (B12, B8A, B4)



Moisture Index
(B8A-B11)/(B8A+B11)



Vegetation Index
VI =(B8-B4)/(B8+B4)

Color Infrared (B8, B4, B3)

DEM (Digital Elevation Model)

3D representation of a topographic surface

Types of DEMs:

- **Digital Surface Model (DSM)**: Represents the Earth's surface and includes all objects on it.
- **Digital Terrain Model (DTM)**: Represents the bare ground surface without any objects like plants and buildings.

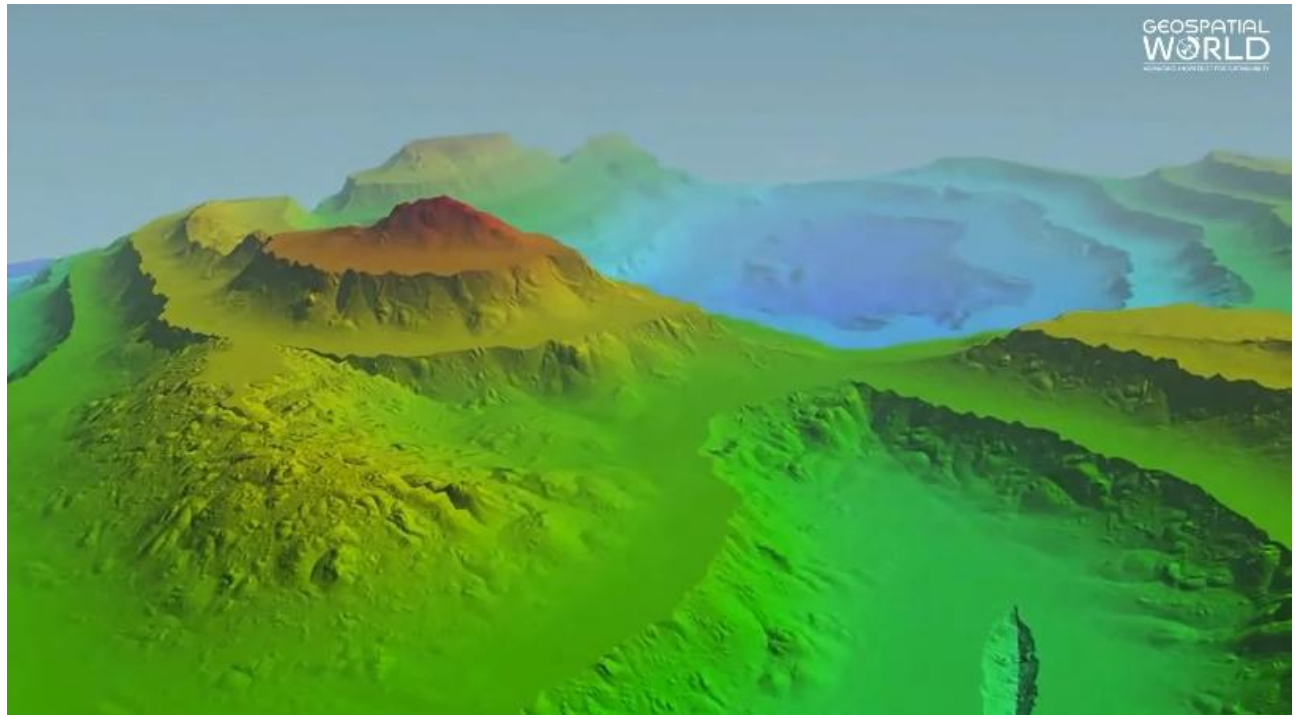


Fig :DEM

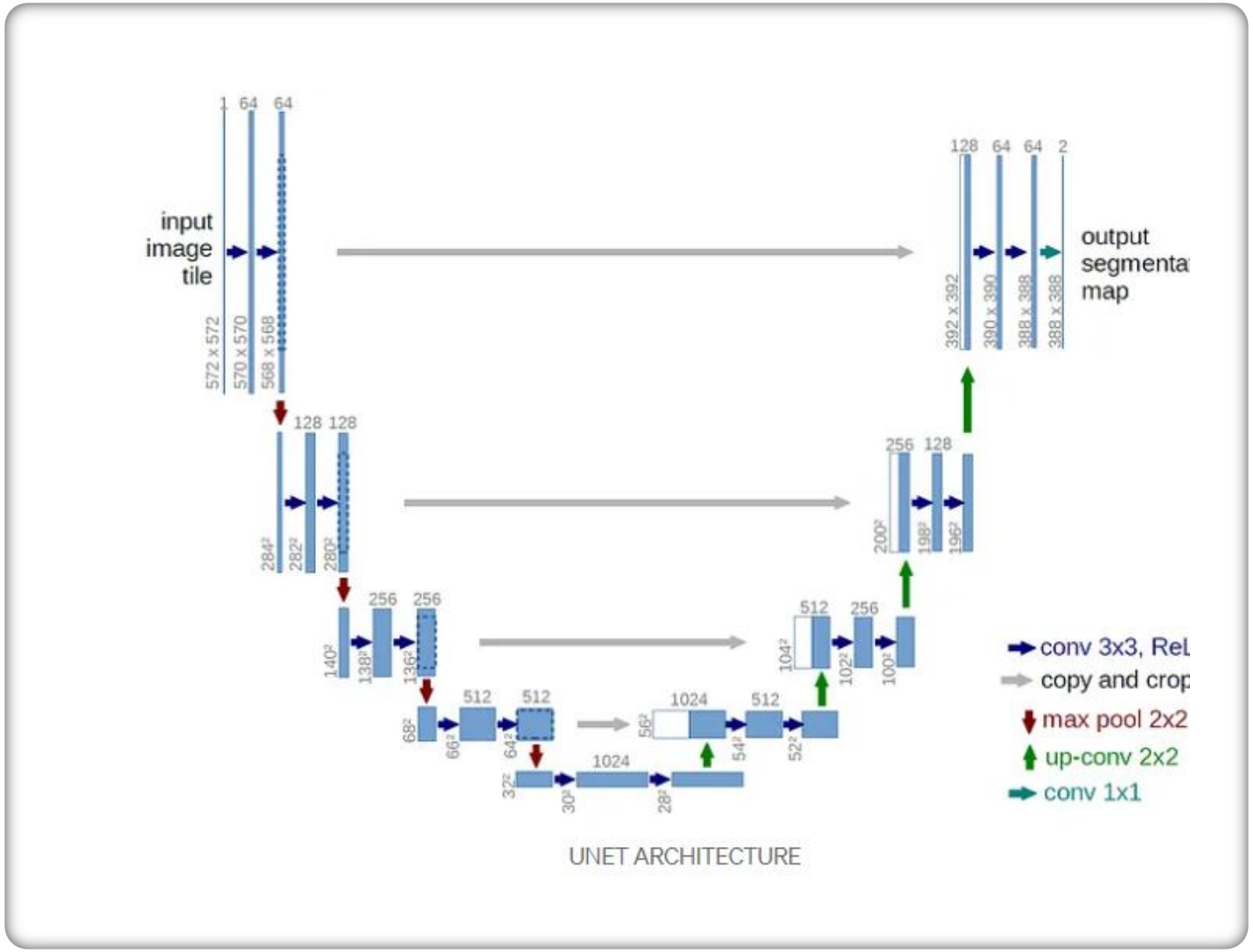
SLOPE DATA

- Gives information about **steepness** or **gradient**
- Quantifies the inclination of the terrain, indicating whether it is **flat**, **gently sloping**, or **steep**

- In a slope map:
  - Flat Areas shown in **Gray**.
  - Gentle Slopes: Represented in **green**, indicating a slight but noticeable incline.
  - Moderate Slopes: shown in **yellow** or **orange**.
  - Steep Slopes: Typically depicted in **red** or **brown**.

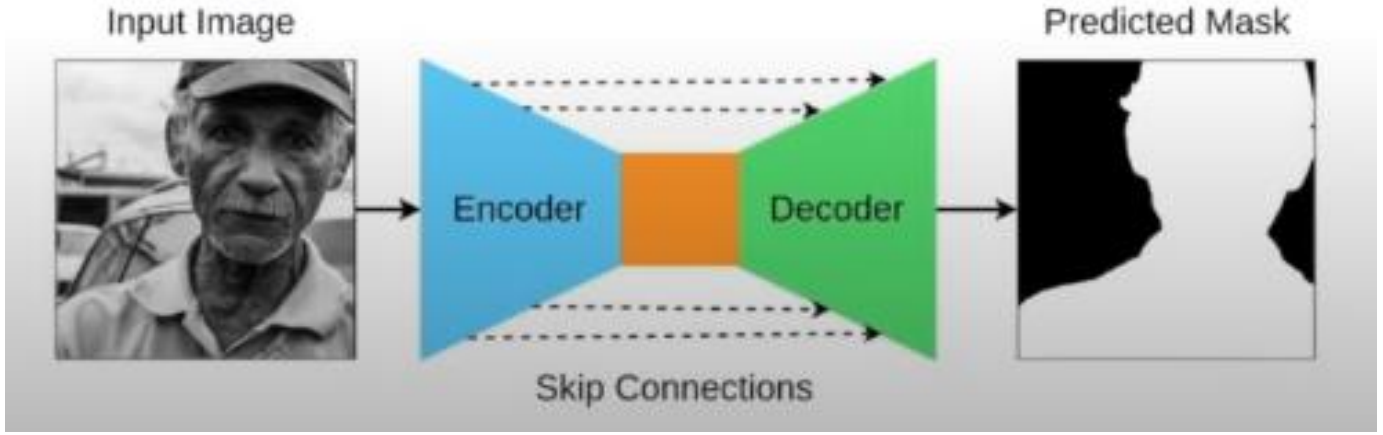
U-NET

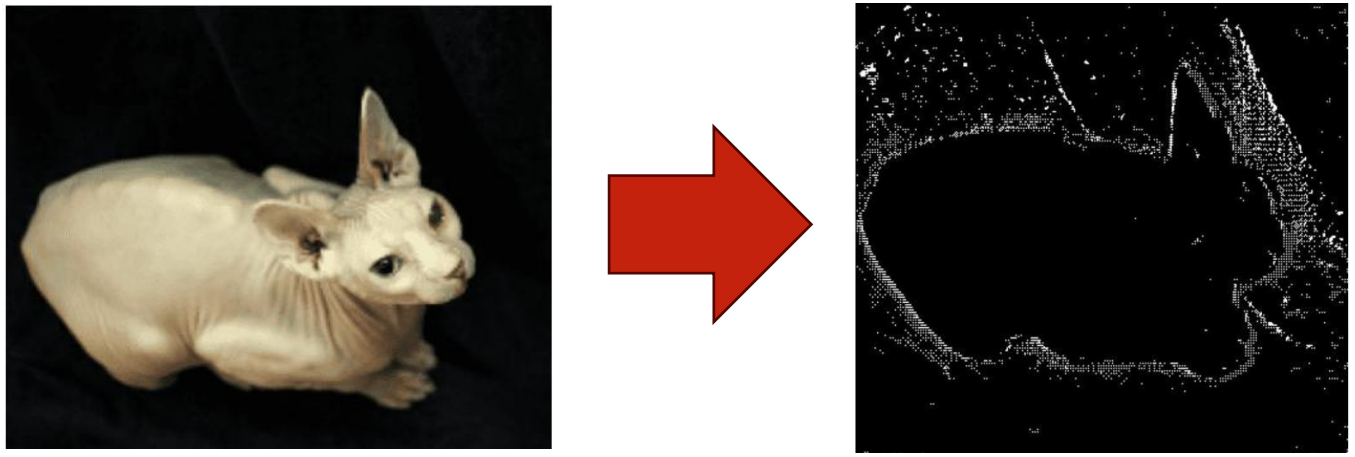
- CNN architecture for fast and precise **segmentation** of images.
- U-shaped Encoder and Decoder Architecture
- Left >> **encoder network**
- Right >> **Decoder Network**
- **Skip Connections**



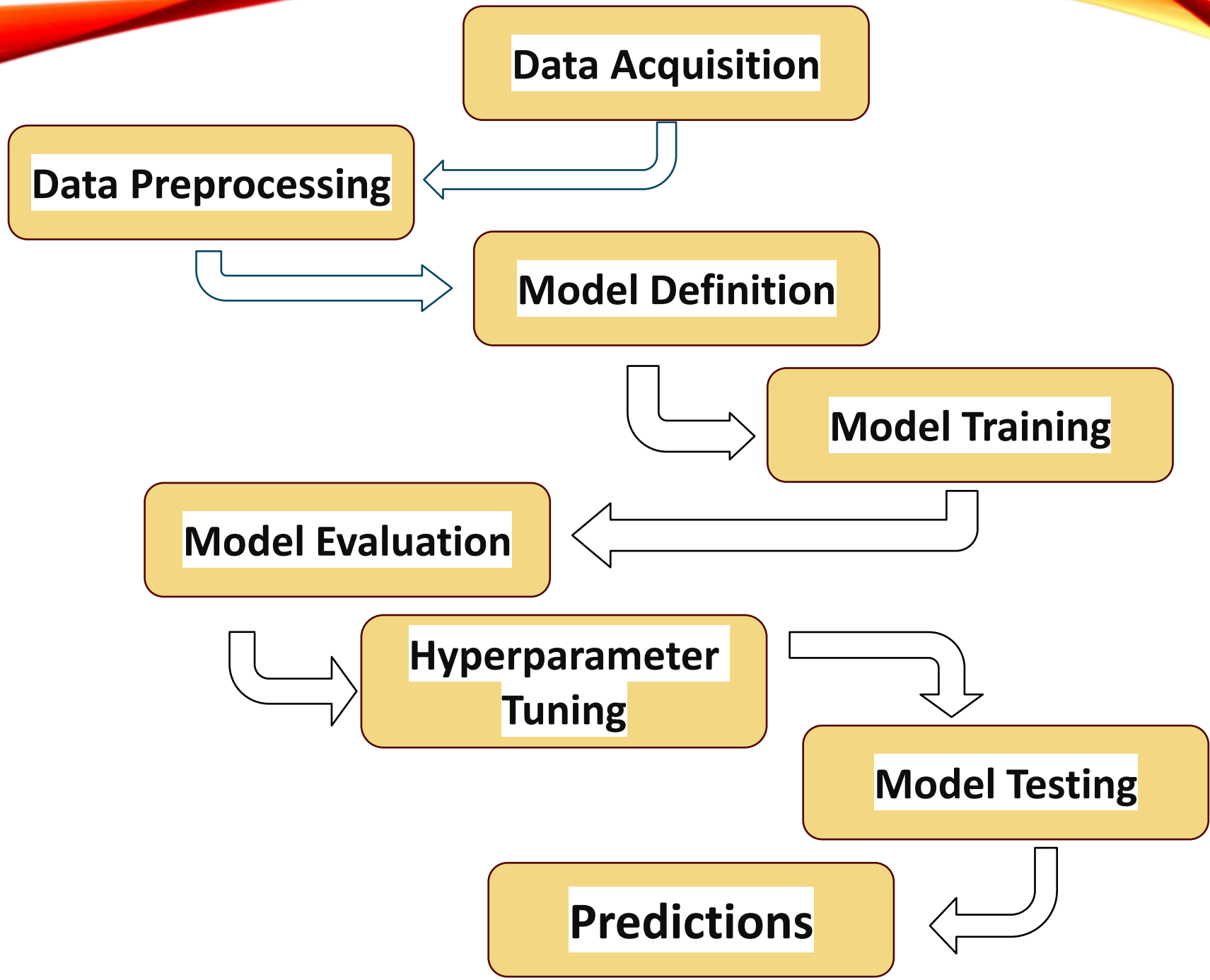
EXAMPLE

- encoder receives the input image
- extracts useful features from that image
- decoder then up samples the features
- we get a segmentation mask



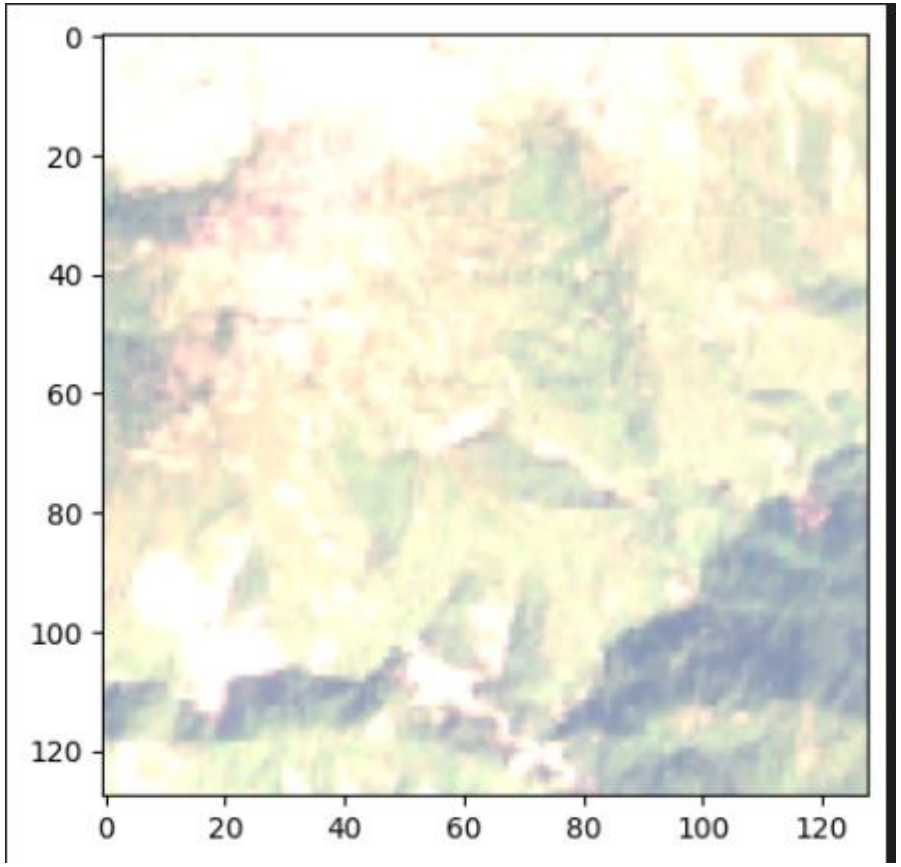


Project Workflow Diagram

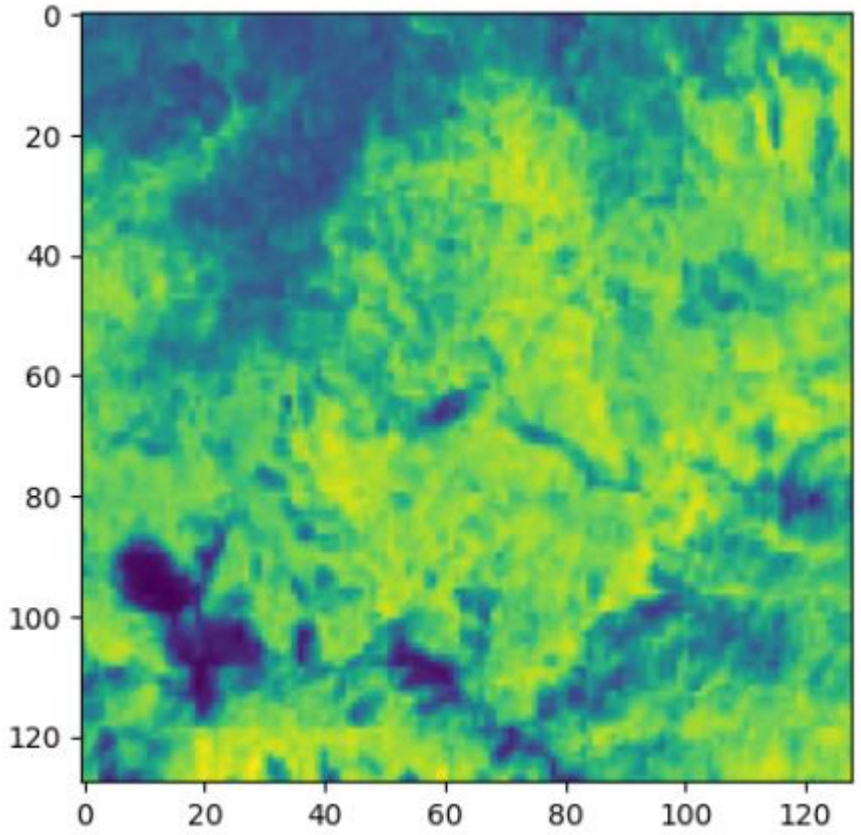


Evaluation:

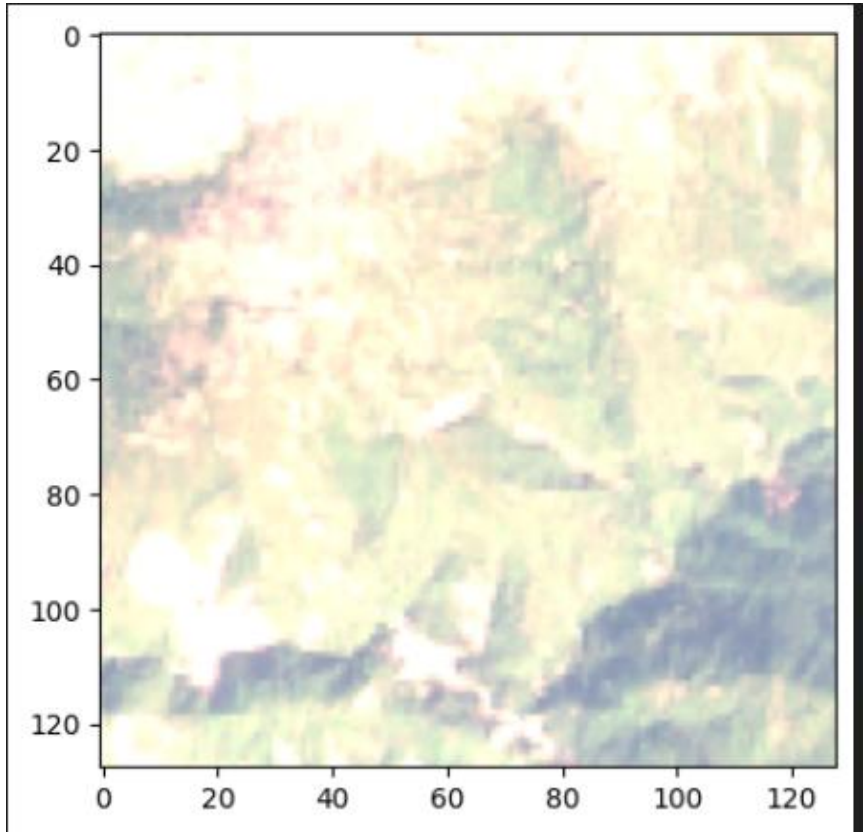
Normal(RGB) Image to NDVI image:



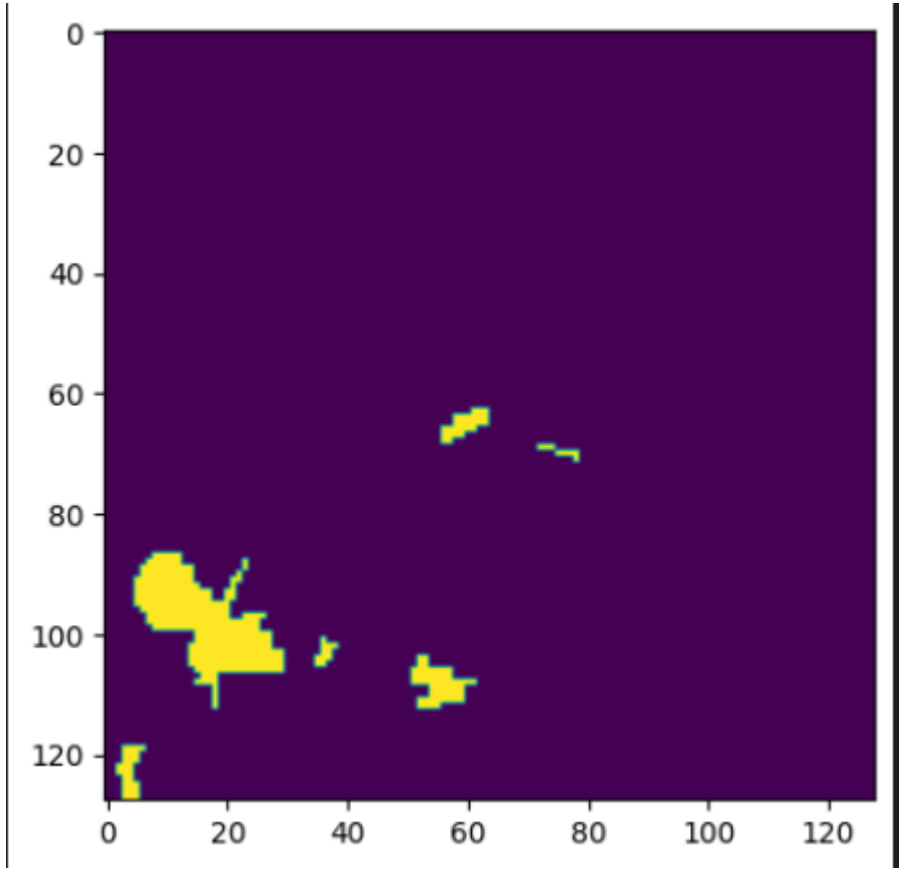
RGB



NDVI

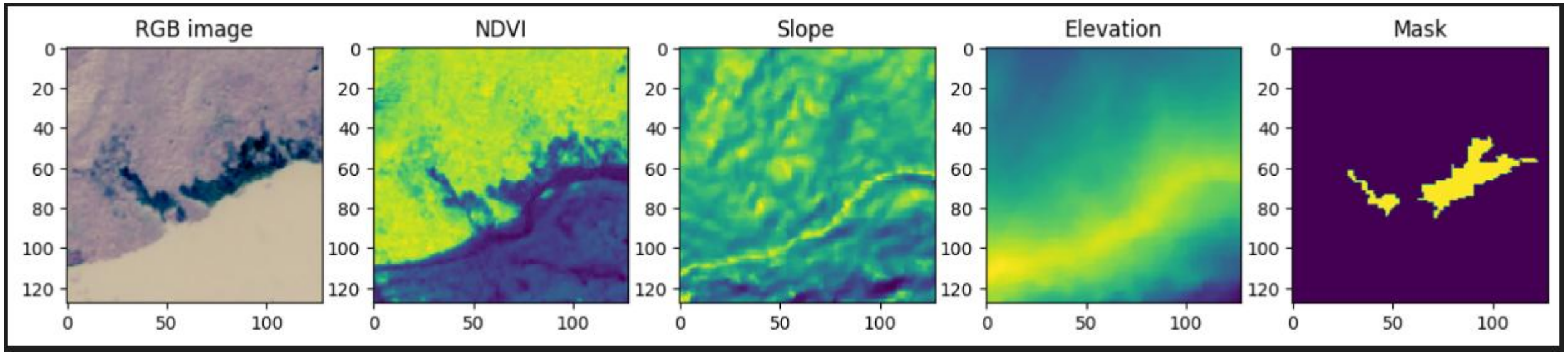


RGB

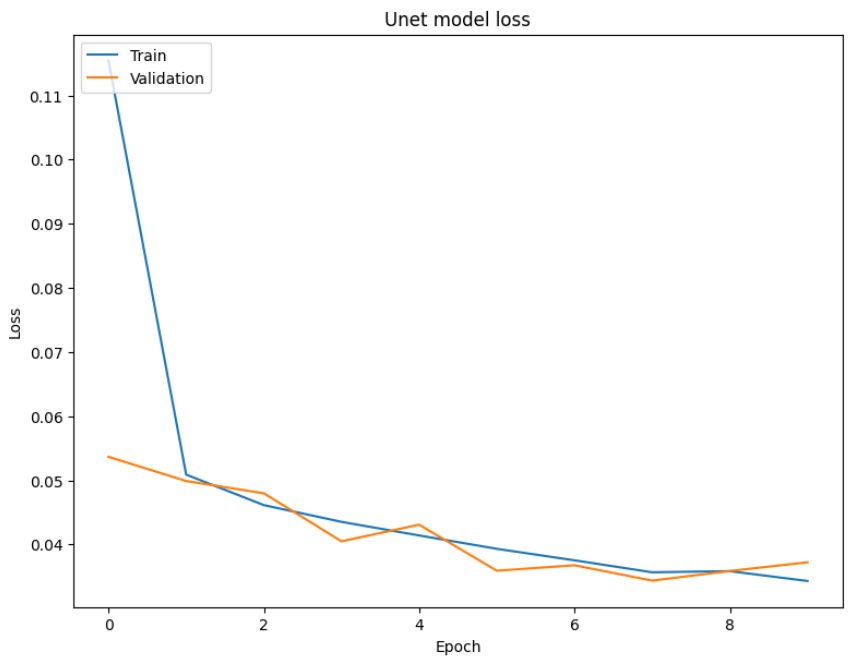


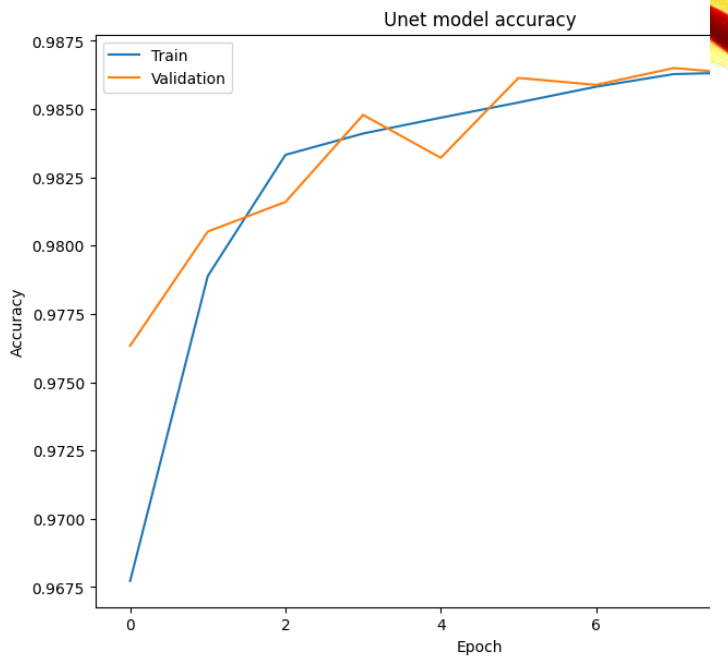
Labelled Data

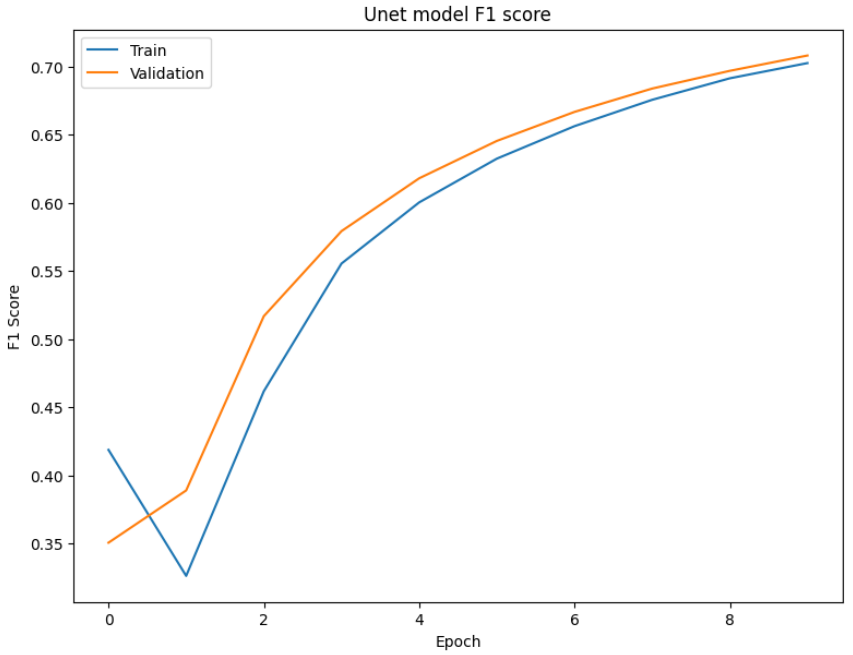
visualization of training data

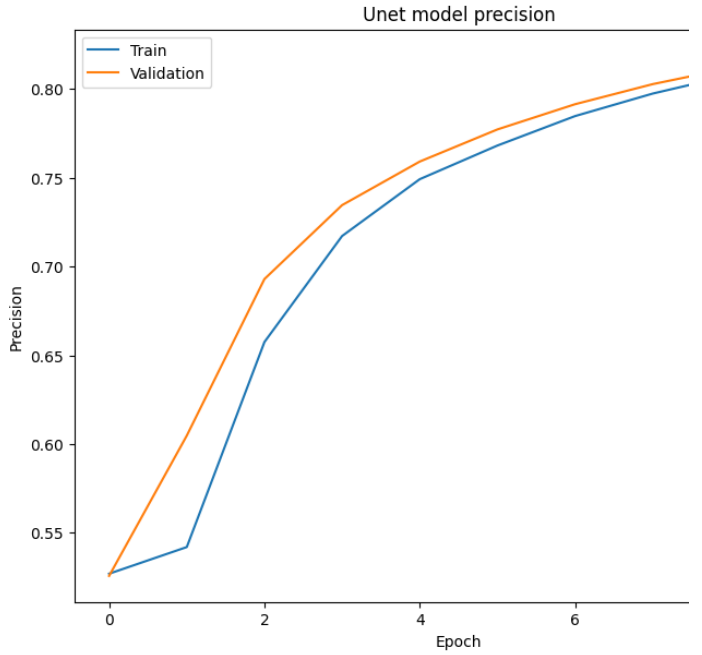


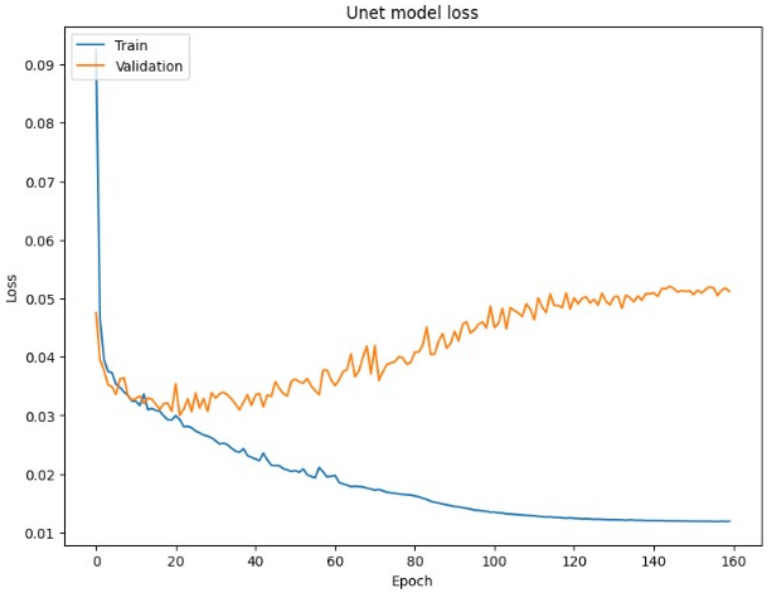
- performance metrics of the U-Net model

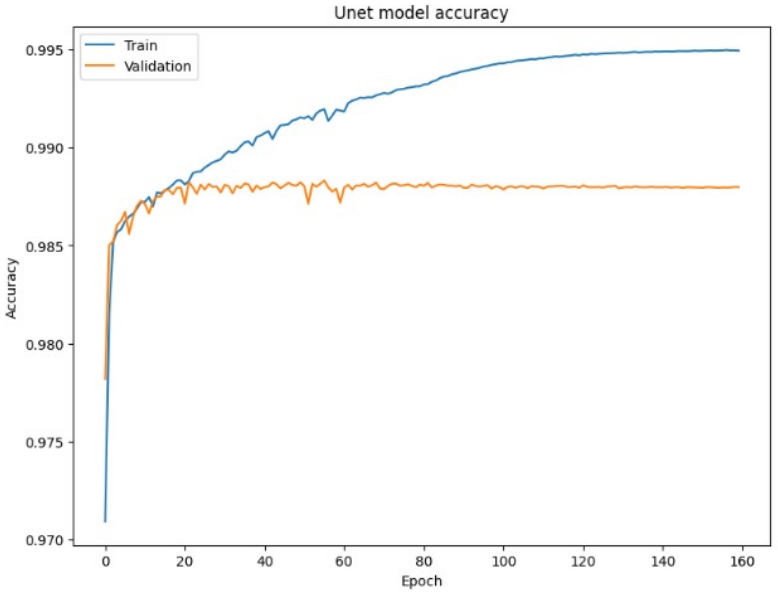


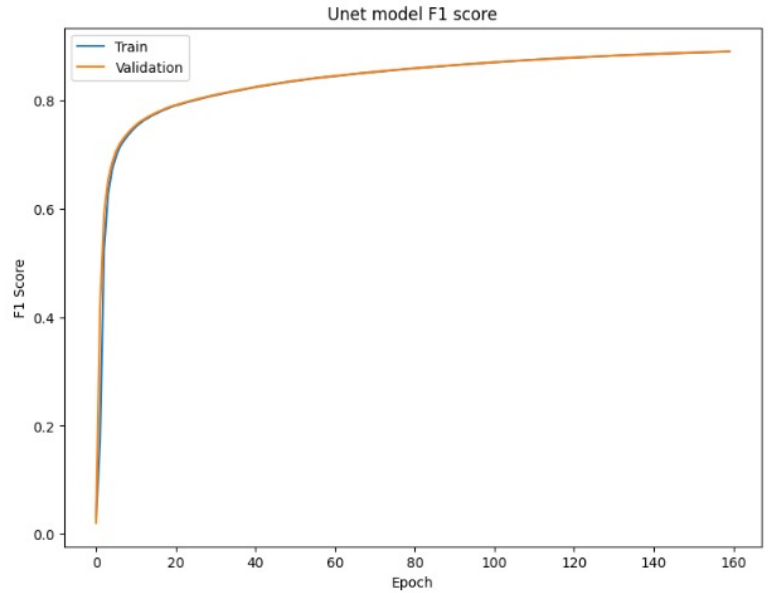


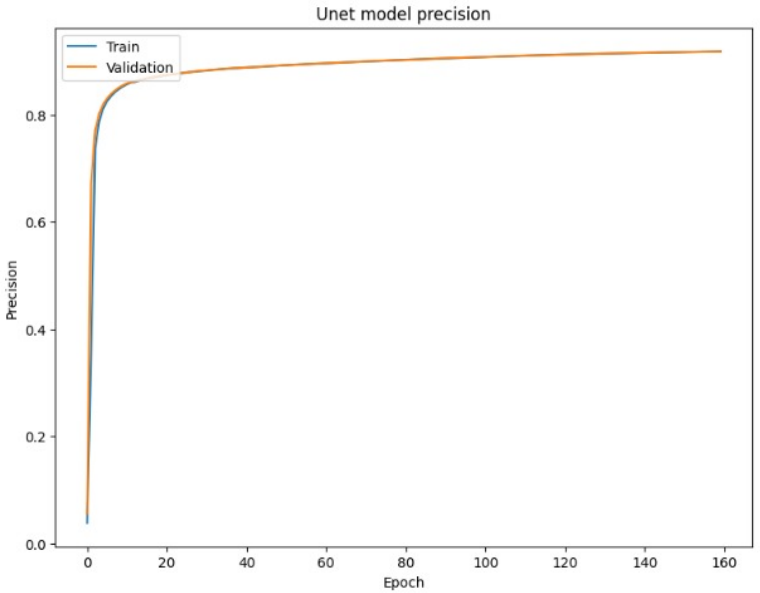


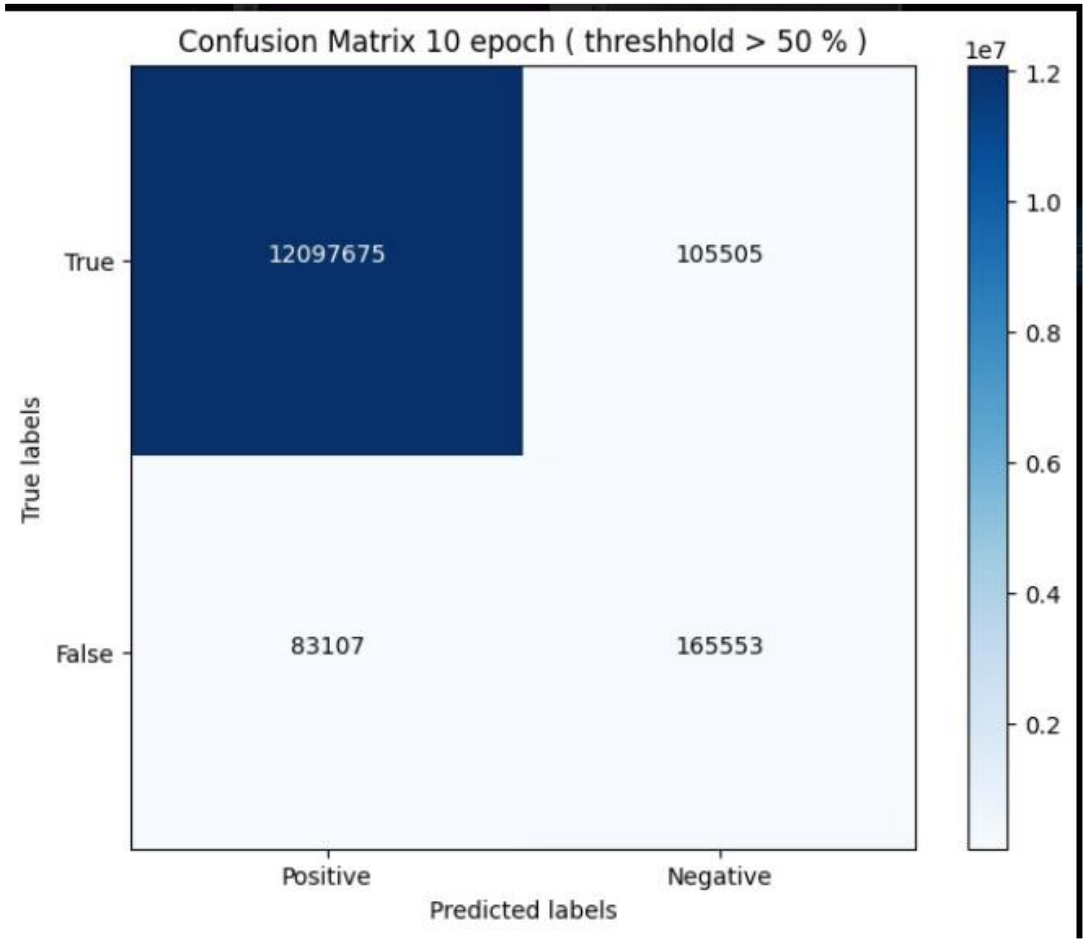


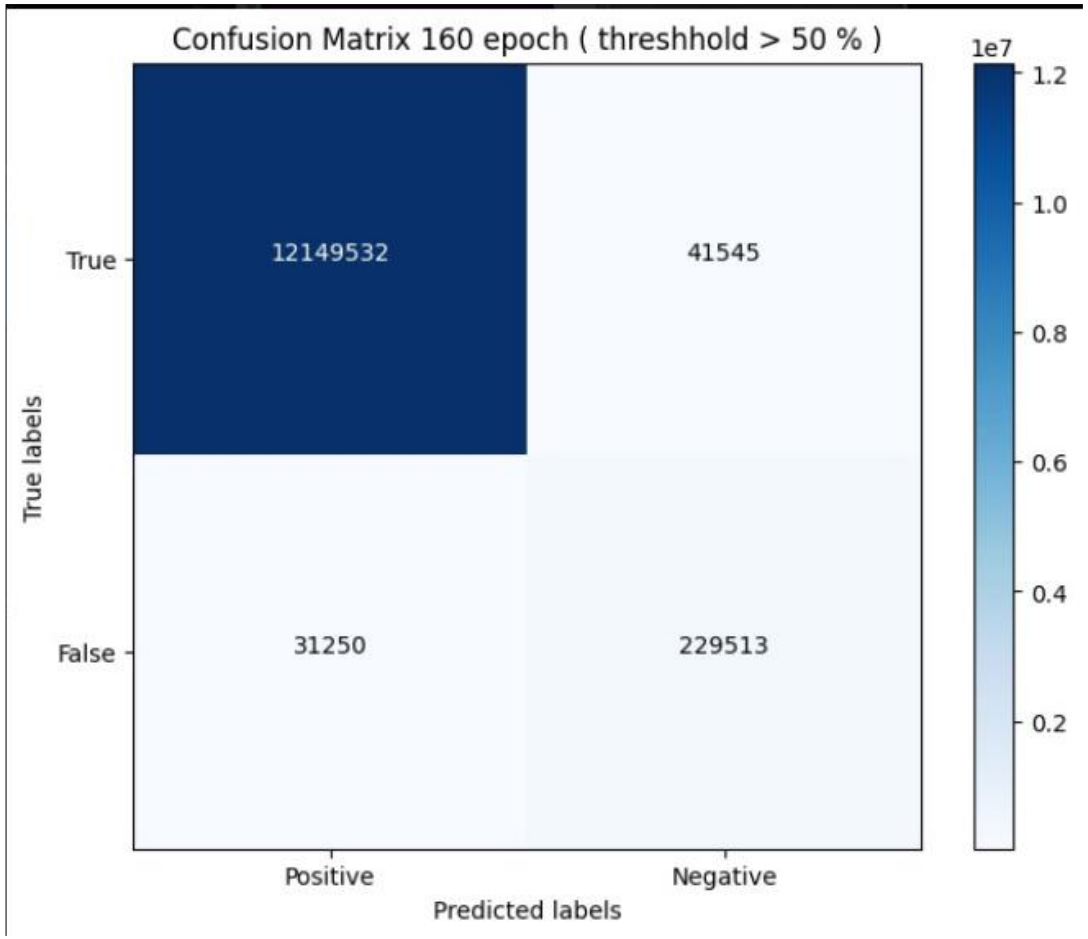

Unet model loss
Train
Validation
Loss
Epoch

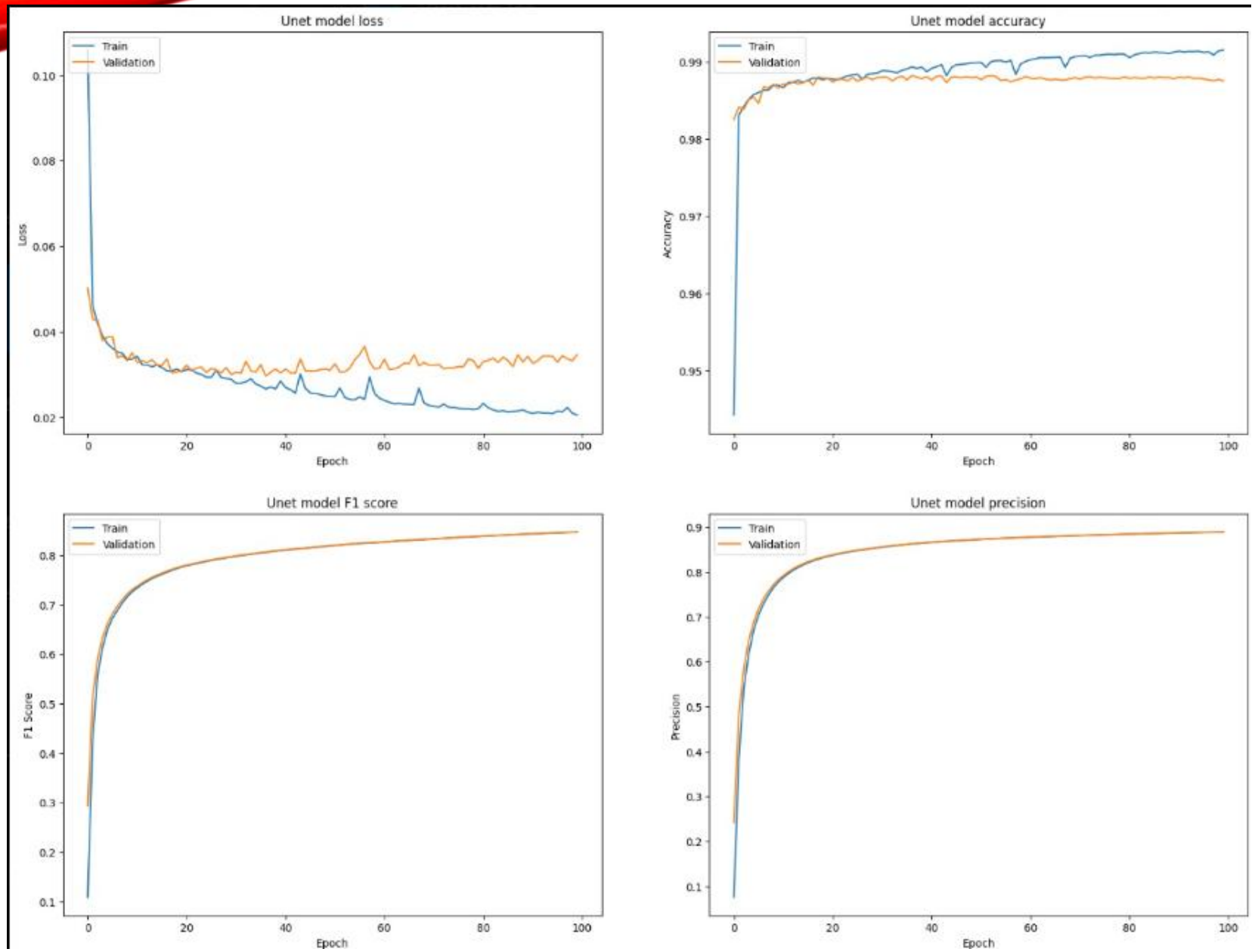

Unet model accuracy
Train
Validation
Accuracy
Epoch


Unet model F1 score
Train
Validation
F1 Score
Epoch

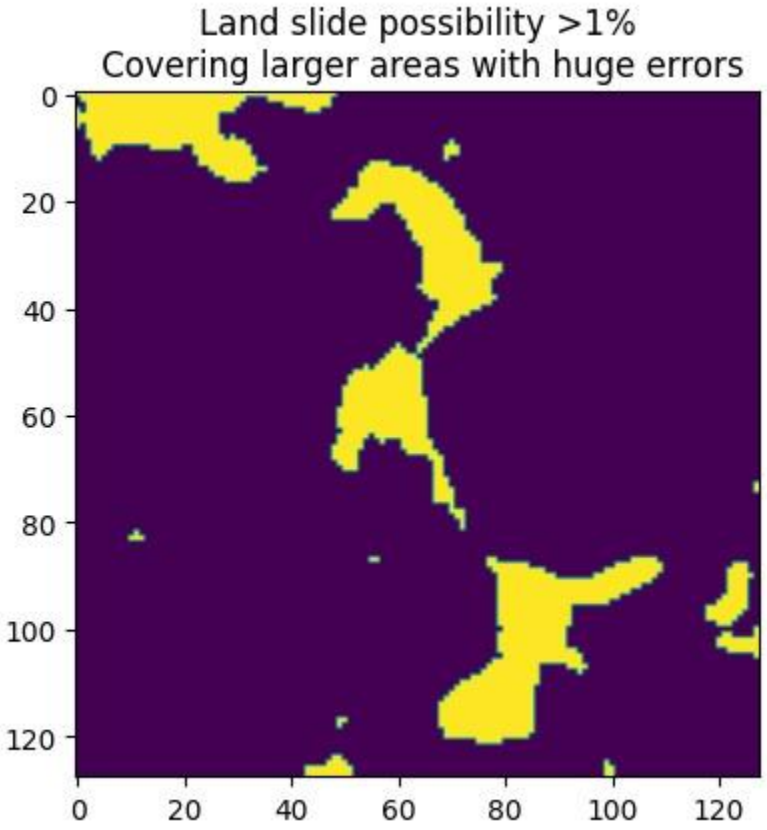

Unet model precision
Train
Validation
Precision
Epoch

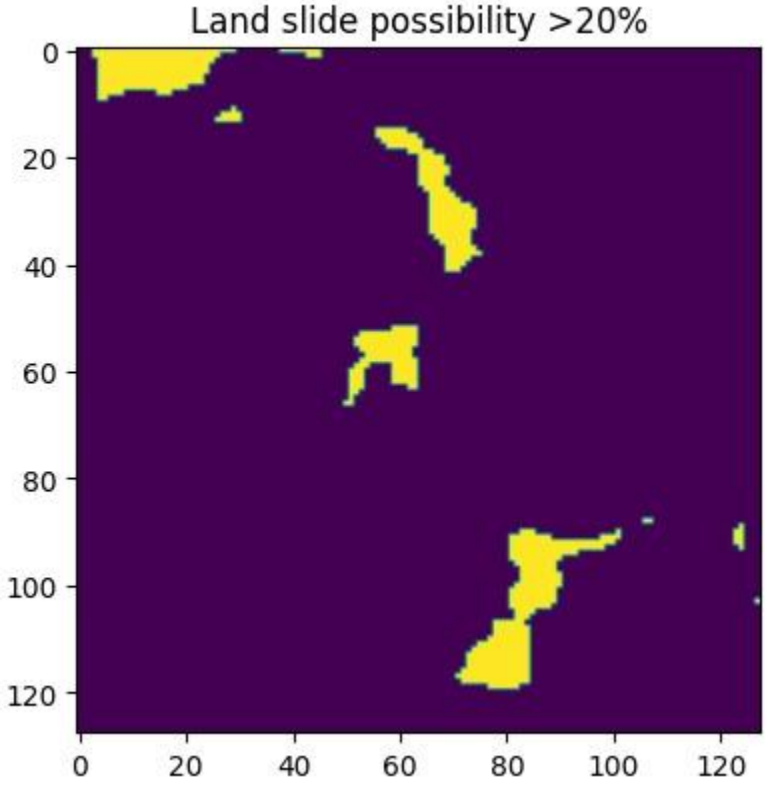

Confusion Matrix 10 epoch (threshhold > 50 %)
1e7
1.2
1.0
0.8
0.6
0.4
0.2
True
False
12097675
105505
83107
165553
True labels
Positive
Negative
Predicted labels

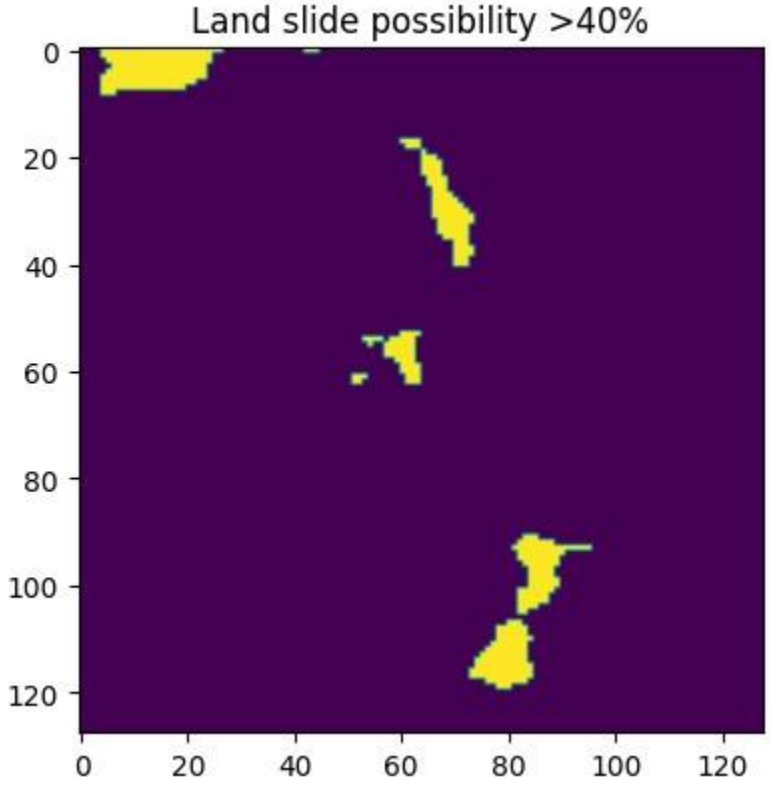

Confusion Matrix 160 epoch (threshhold > 50 %)
1e7
1.2
1.0
0.8
0.6
0.4
0.2
True
False
12149532
41545
31250
229513
True labels
Positive
Negative
Predicted labels

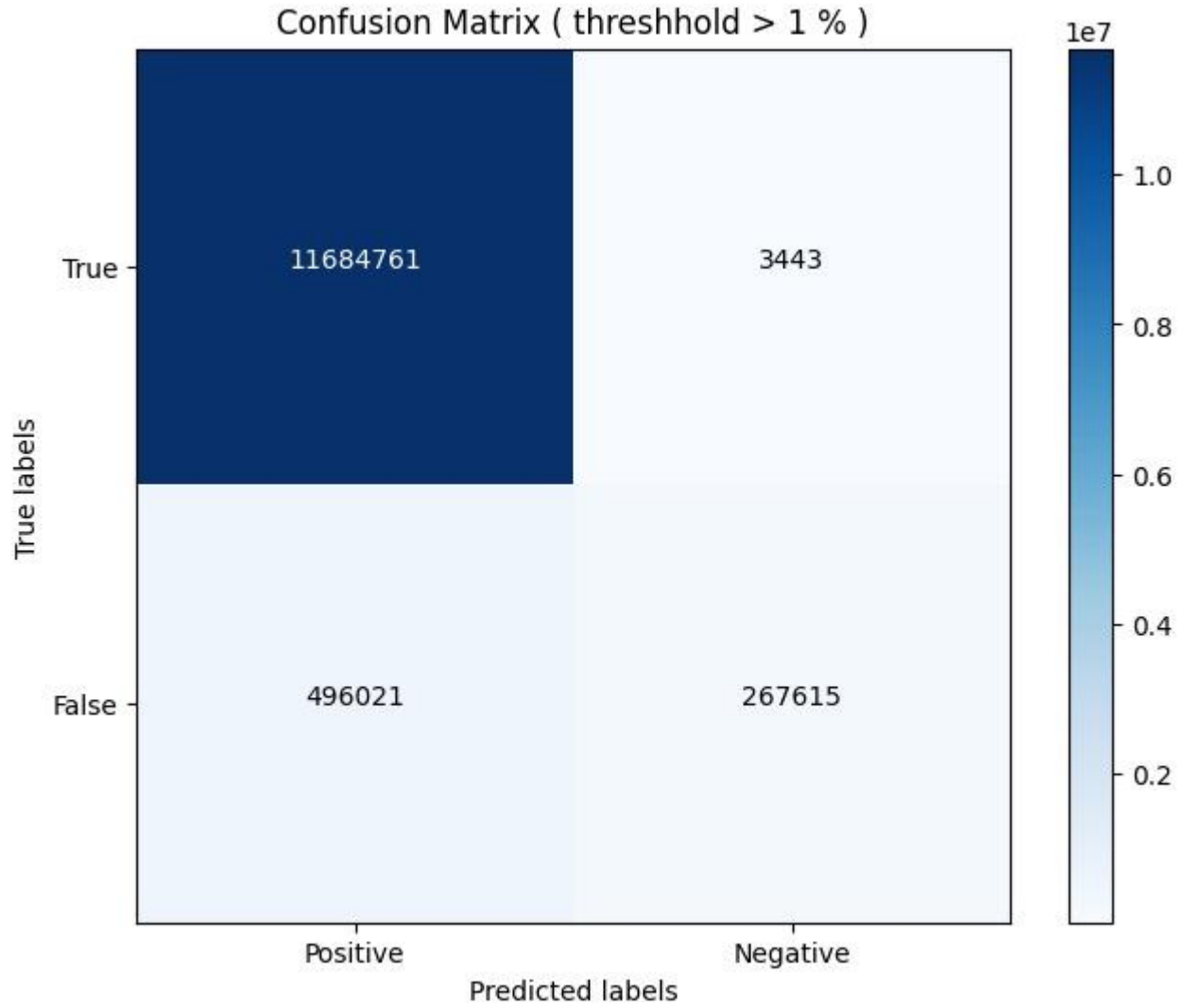

Unet model loss
Train
Validation
Loss
Epoch
Unet model accuracy
Train
Validation
Accuracy
Epoch
Unet model F1 score
Train
Validation
F1 Score
Epoch
Unet model precision
Train
Validation
Precision
Epoch

Values with Low precision and High recall

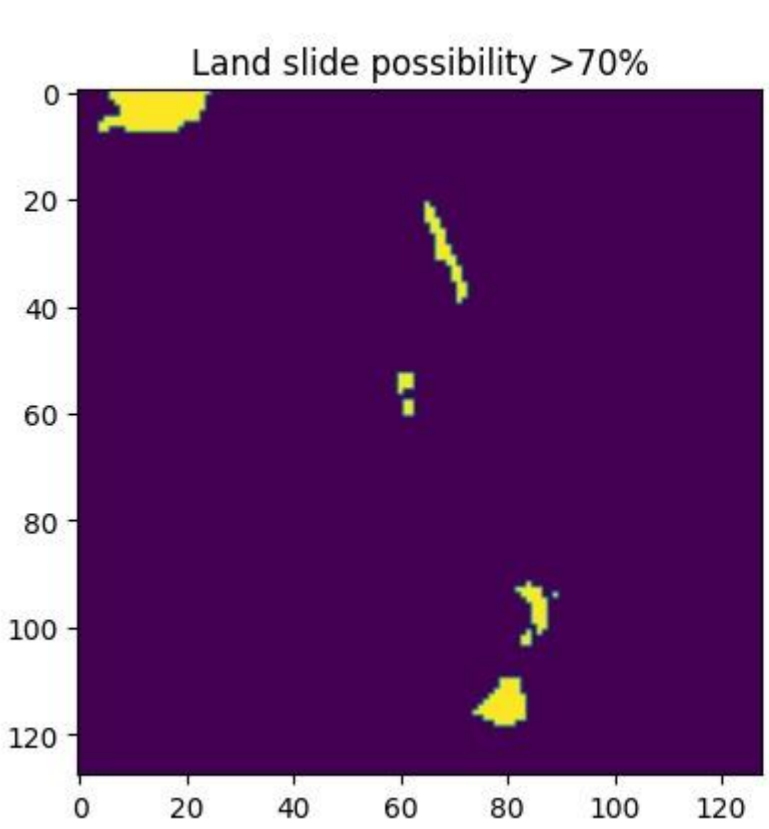


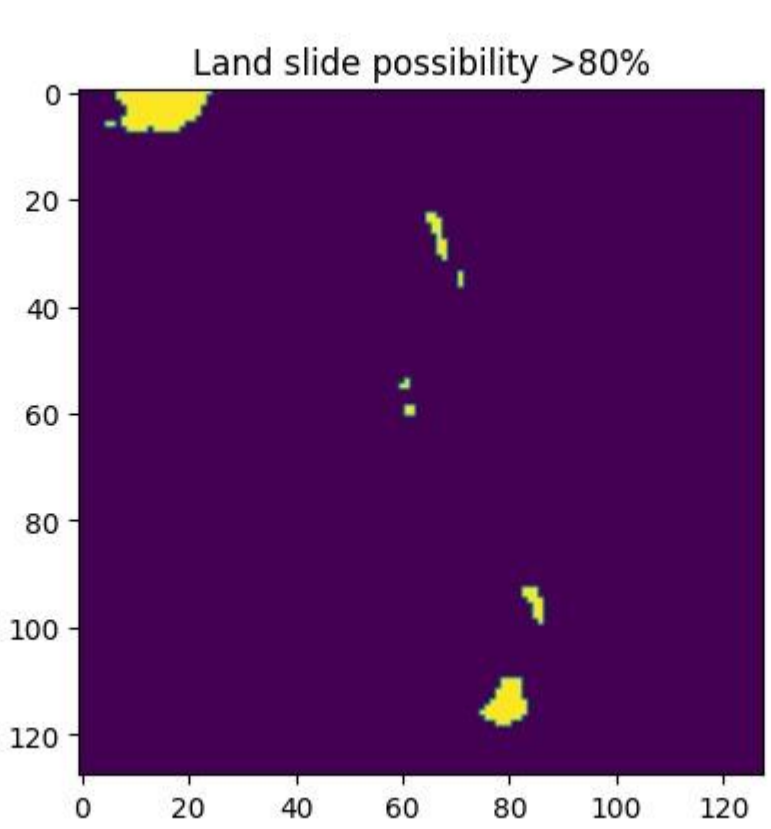


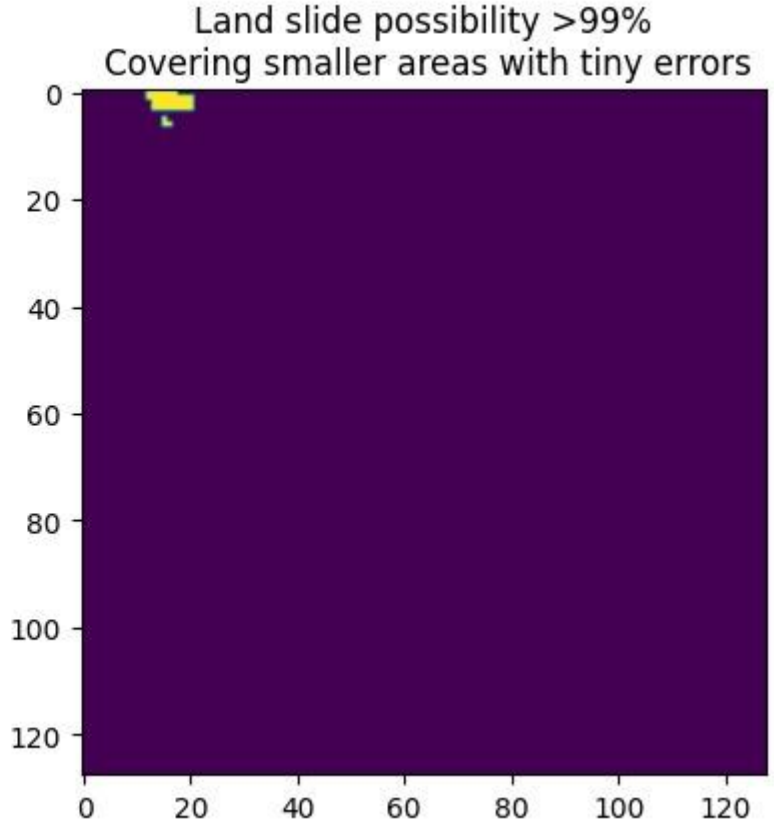


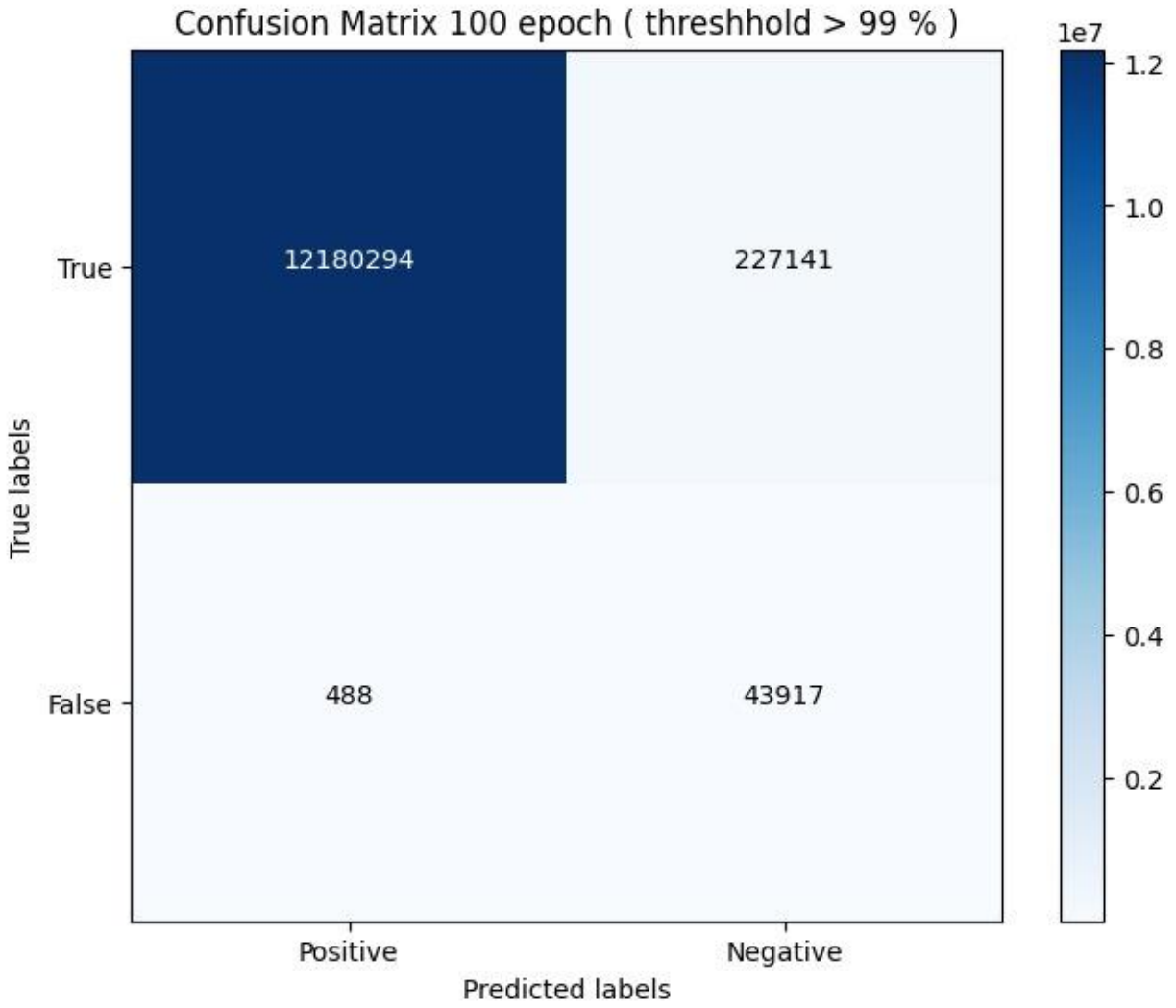

Confusion Matrix (threshhold > 1 %)
1e7
1.0
0.8
0.6
0.4
0.2
True
False
True labels
11684761
3443
496021
267615
Positive
Negative
Predicted labels

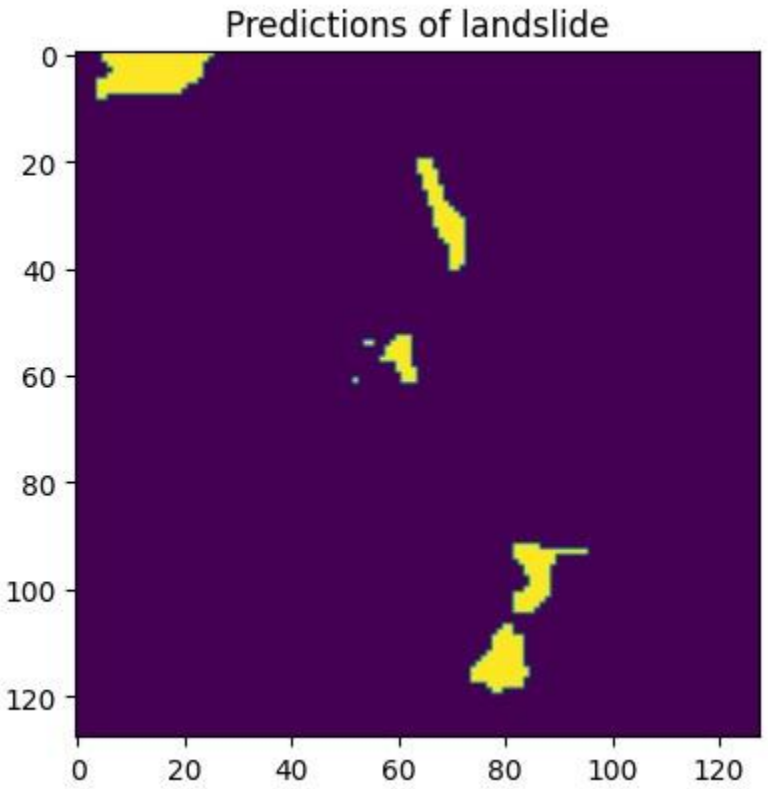
Values with High precision and Low recall

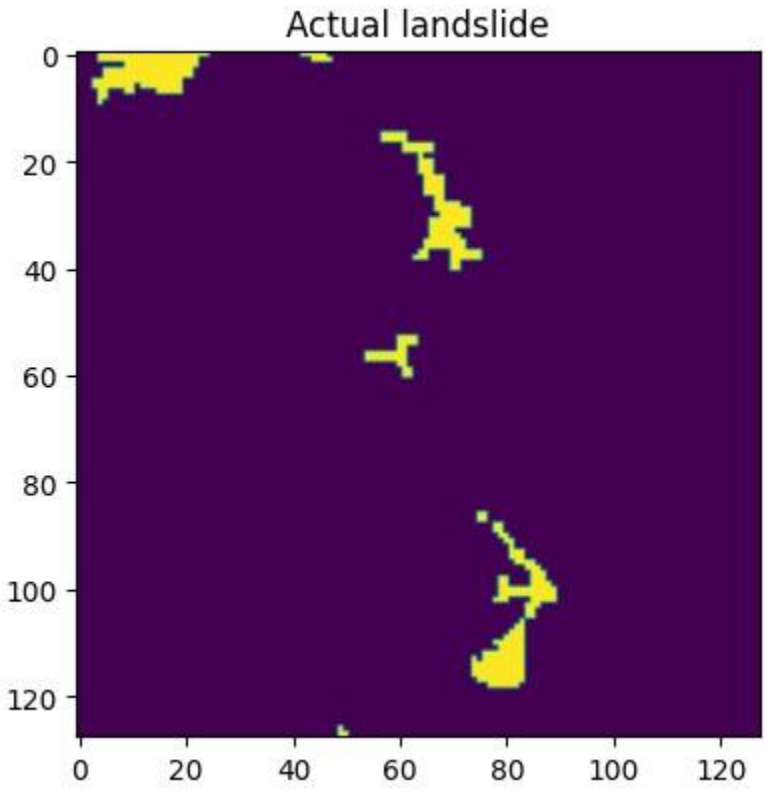


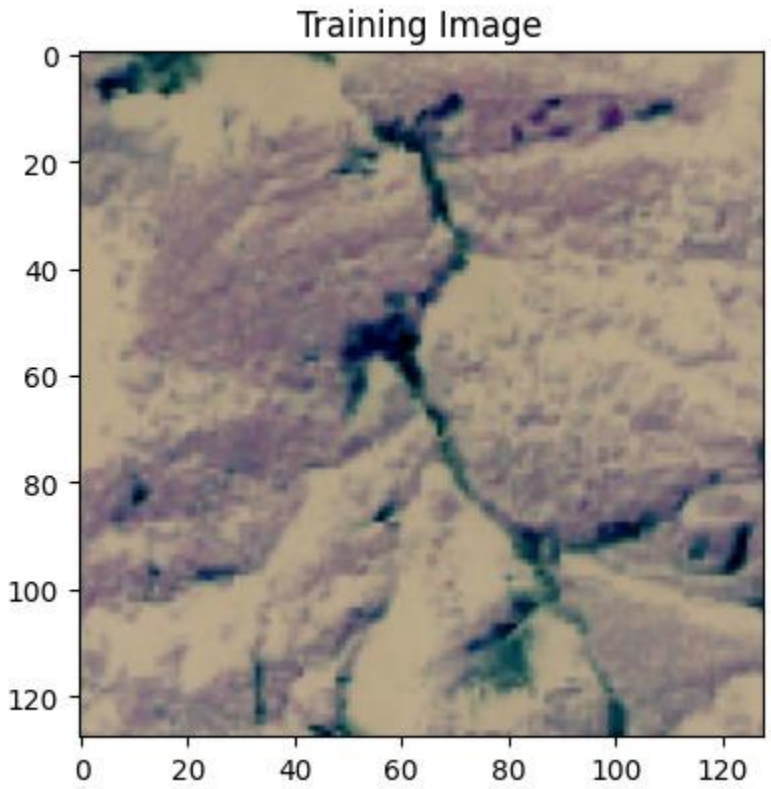


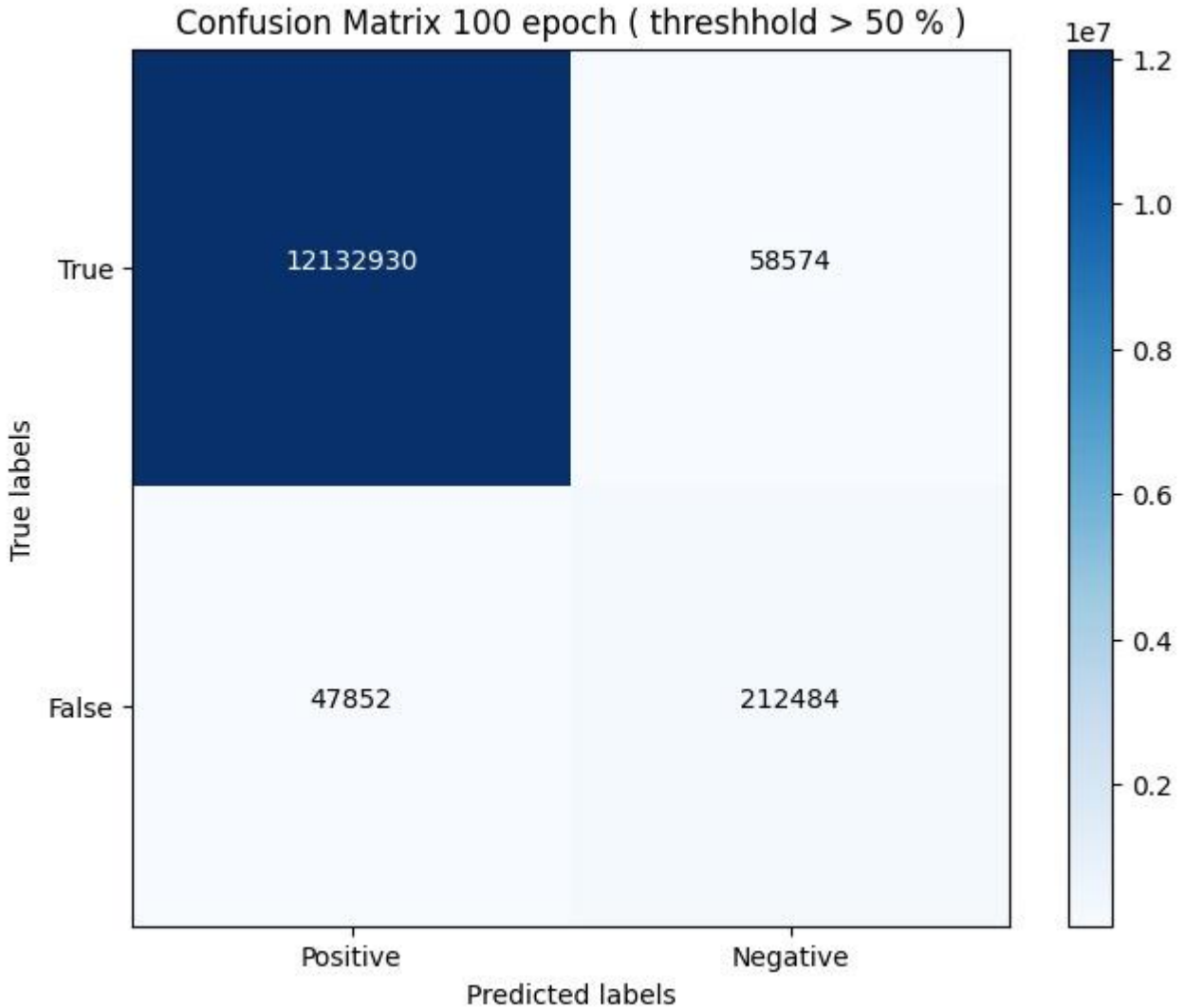



Confusion Matrix 100 epoch (threshhold > 99 %)
1e7
1.2
1.0
0.8
0.6
0.4
0.2
True
False
12180294
227141
488
43917
True labels
Positive
Negative
Predicted labels

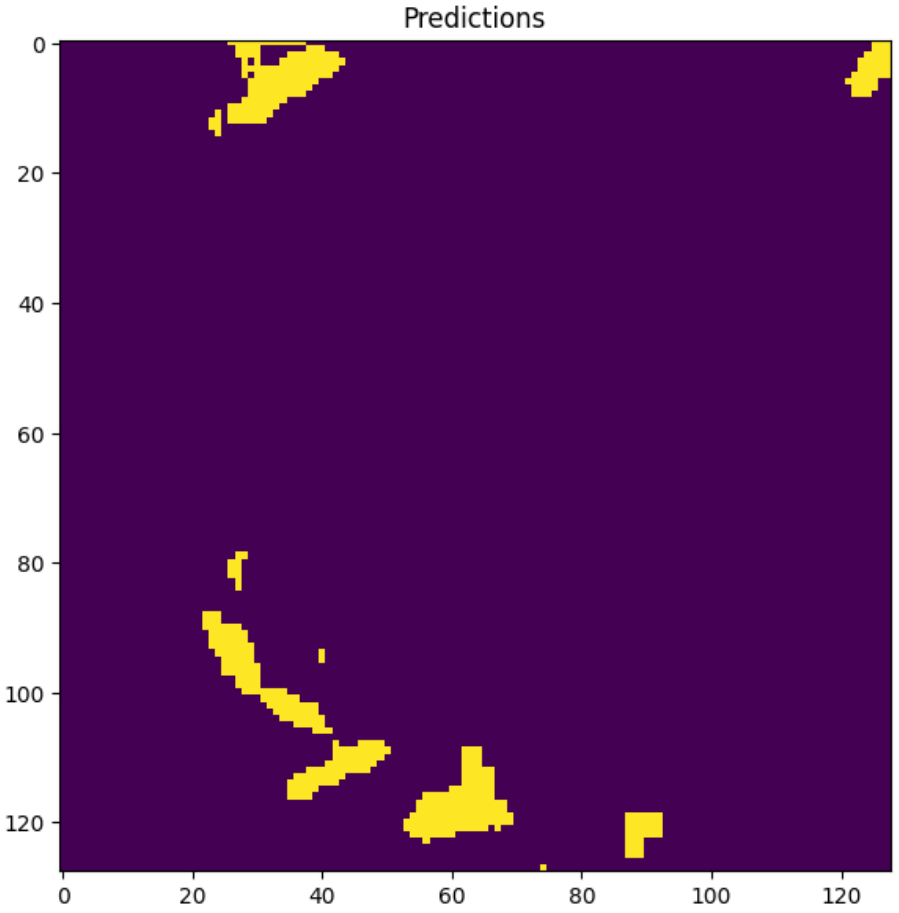

Predictions of landslide
0
20
40
60
80
100
120
0
20
40
60
80
100
120

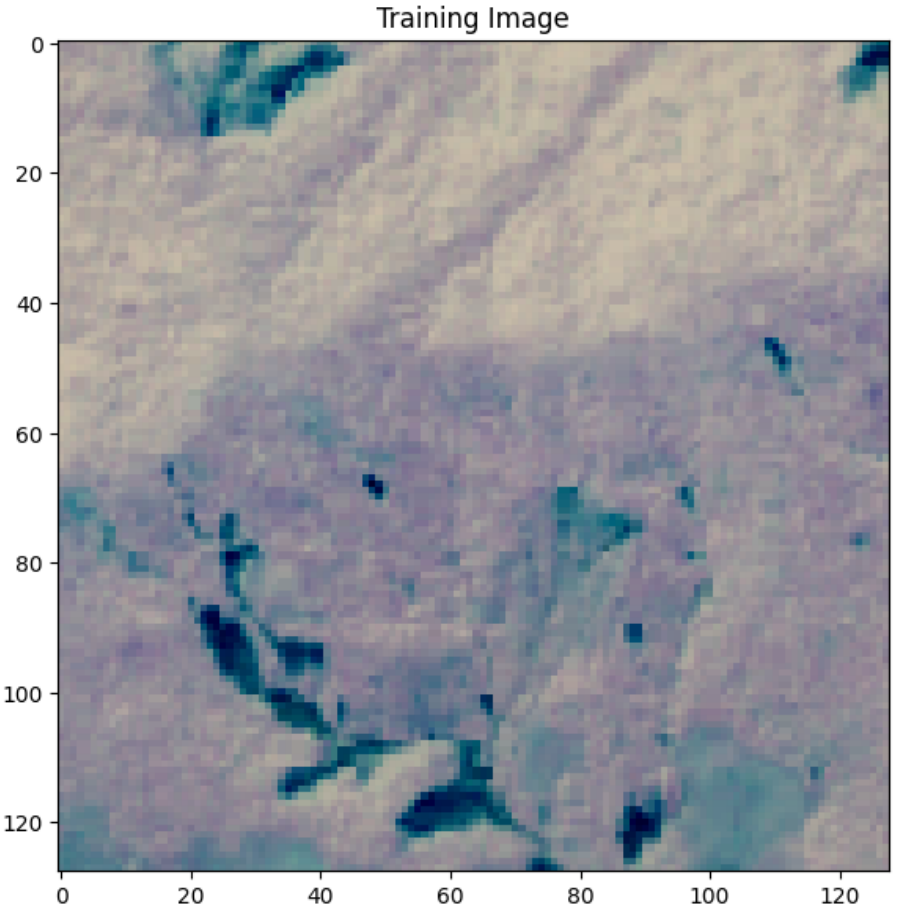

Actual landslide
0
20
40
60
80
100
120
0
20
40
60
80
100
120


Training Image
0
20
40
60
80
100
120
0
20
40
60
80
100
120


Confusion Matrix 100 epoch (threshhold > 50 %)
1e7
1.2
1.0
0.8
0.6
0.4
0.2
True
False
12132930
58574
47852
212484
True labels
Positive
Negative
Predicted labels

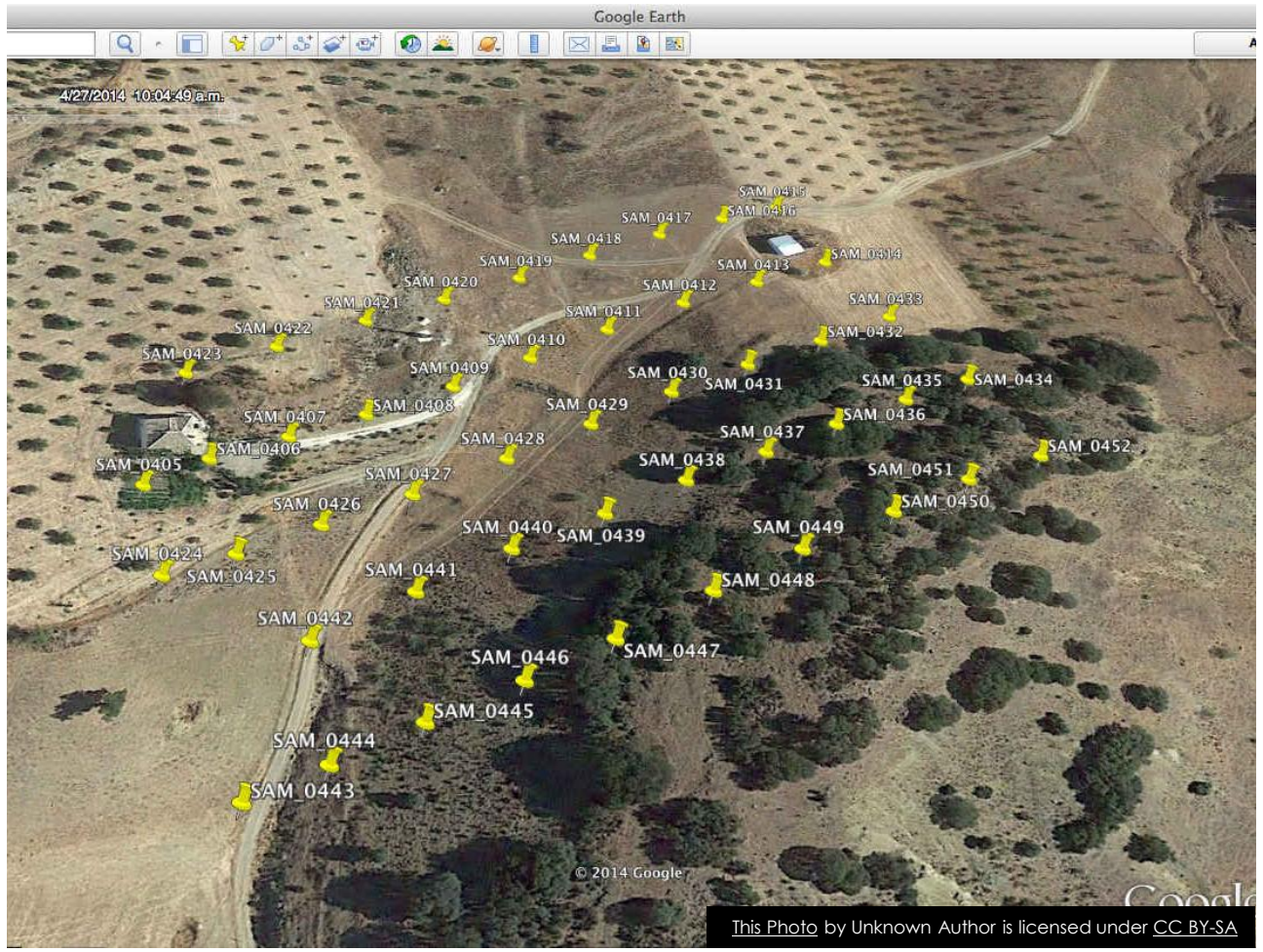
Final Prediction





THE FUTURE SCOPE AND APPLICATION

- **Improved Accuracy and Efficiency**
- **Integration with Disaster Management Systems**
- **Precision Agriculture and Environmental Monitoring:**
- **Urban Planning and Infrastructure Development**
- **Climate Change Adaptation**



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