An evaluation of current status of glaciers in the Western United States using machine learning algorithms and Sentinel-2A images

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Why study glaciers?

- Continuous increase in warming is having a significant effect on glaciers.
- Glacier shrinkage and reduction are mostly attributed to climate change because the smallest change in climate has a very significant effect on glaciers. Hence, glaciers are extremely important for detecting climate change.
- The rapid shrinkage of glaciers due to global warming and climate change has various consequences, such as rising sea levels, changes in hydrology, and increased natural hazards.

Why study glaciers?

- Several studies conducted on the status of glaciers have noted a significant decline in glaciers in the United States.
- Pelto, (2008) researched on the effect of climate change on 47 glaciers from 1950 to 2005 in the North Cascade Mountain range and found out that all the glaciers are declining with 4 of them disappearing completely.
- Basagic & Fountain, (2011) studied glaciers in Sierra Nevada from 1903 to 2004 and noted that there is a decrease in area of about 39.86 ± 9.59 sq.Km (56%).
- O’Neel et al., 2019 studied the US Geological Survey Benchmark Glaciers and noted that all the glaciers are declining at an alarming rate.

Introduction

- GLIMS: Global Land Ice Measurements from Space is an internationally collaborated project that provides detailed boundaries of glaciers for the entire world.
- The GLIMS database has a record of US glaciers, which was created using topographic maps of 1:100K and 1:24K scales, derived from aerial photographs captured between 1949 to 1989.
- There is no recent update on glacier conditions in the US, hence this research provides insight into the status of glaciers in the United States.

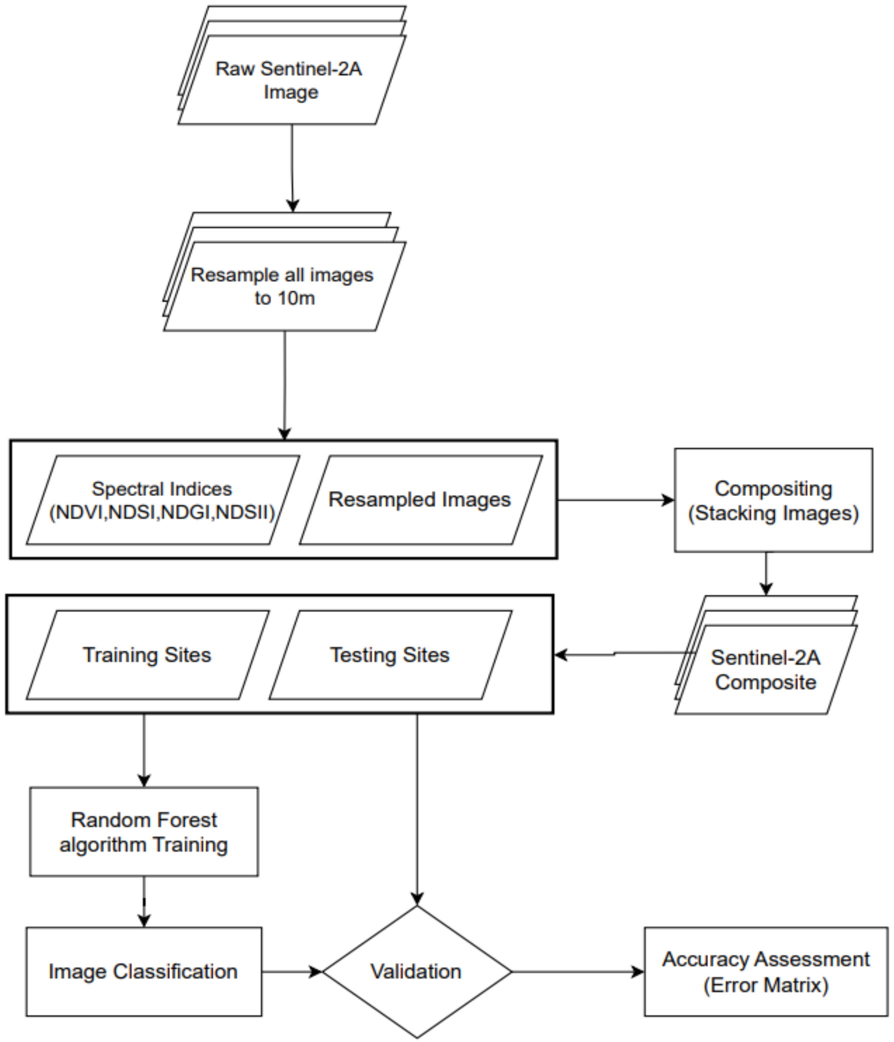
Objective

- To estimate the extent of glacier area and volume changes in the Western United States over a given period of time using Sentinel-2A images.

Data

- Sentinel -2A satellite imagery for September month of 2020
- GLIMS Glaciers boundaries database
- USGS Topographic maps
- Google Earth

Methodology



- Used Random Forest Algorithm for image classification
- Over 26,500 pixels were selected in each image as training site pixels and each pixel was classified as Water, vegetation, barren, snow, shadow, ice, or debris.
- The classified images, topographic maps and google earth images also served as references for detailed manual digitization.

Results

- The random forest machine learning image classification method provided over 98 percent classification accuracy.

- A total of 4155 glaciers with an area of 475.9 (±7.4) sq. km were found in the region.

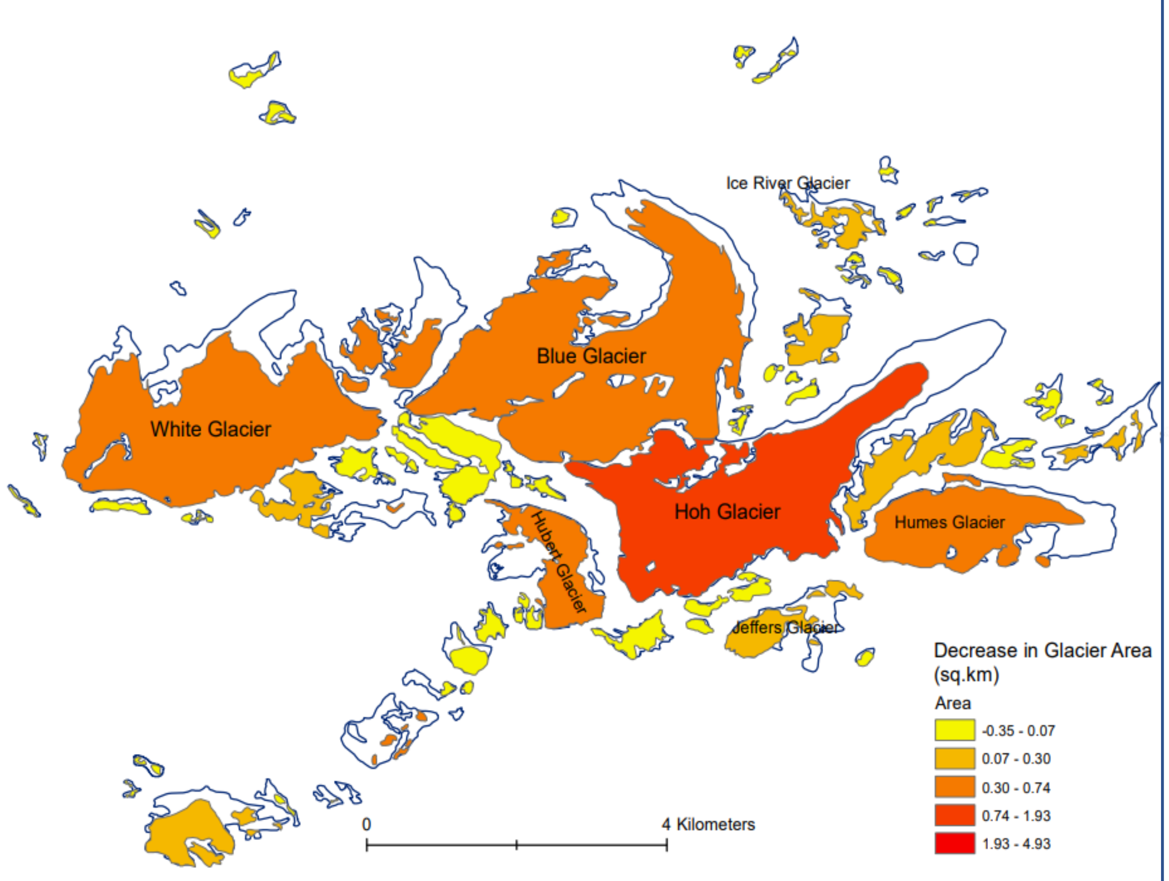
- Over the study the period glaciers in this region experienced significant decrease.

- A decrease of 183.79 (±2.85) sq. km was estimated which represents 27.96% of area lost as compared to the GLIMS database boundaries, with a corresponding volume loss of -69.48 km^3.

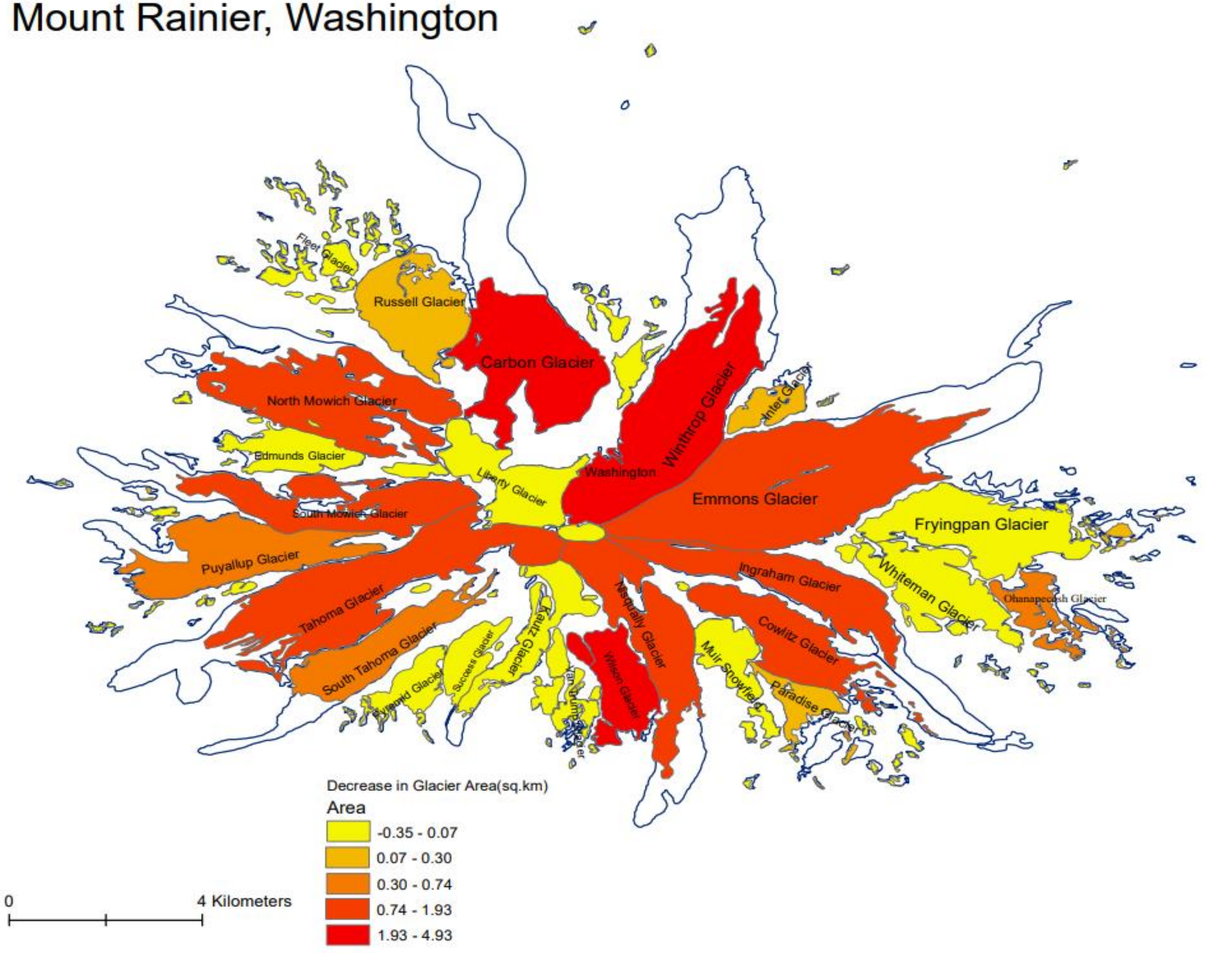
Summary of Glacier Boundary Change

State	Num. of Glaciers	Total Area (2020)	Min Change	Max Change	Mean Change	Sd. Dev.	Percent Change
WA	1817	117.95	-0.35	4.93	0.065	0.25	26.03
OR	182	18.44	-0.13	2.62	0.1	0.28	51.4
CA	604	16.49	-0.16	0.77	0.027	0.06	49.31
MT	730	15.61	-0.11	0.98	0.021	0.07	24.8
WY	788	14.55	-0.13	1.34	0.02	0.08	21.59
ID	34	0.753	-0.007	0.08	0.02	0.02	73.64

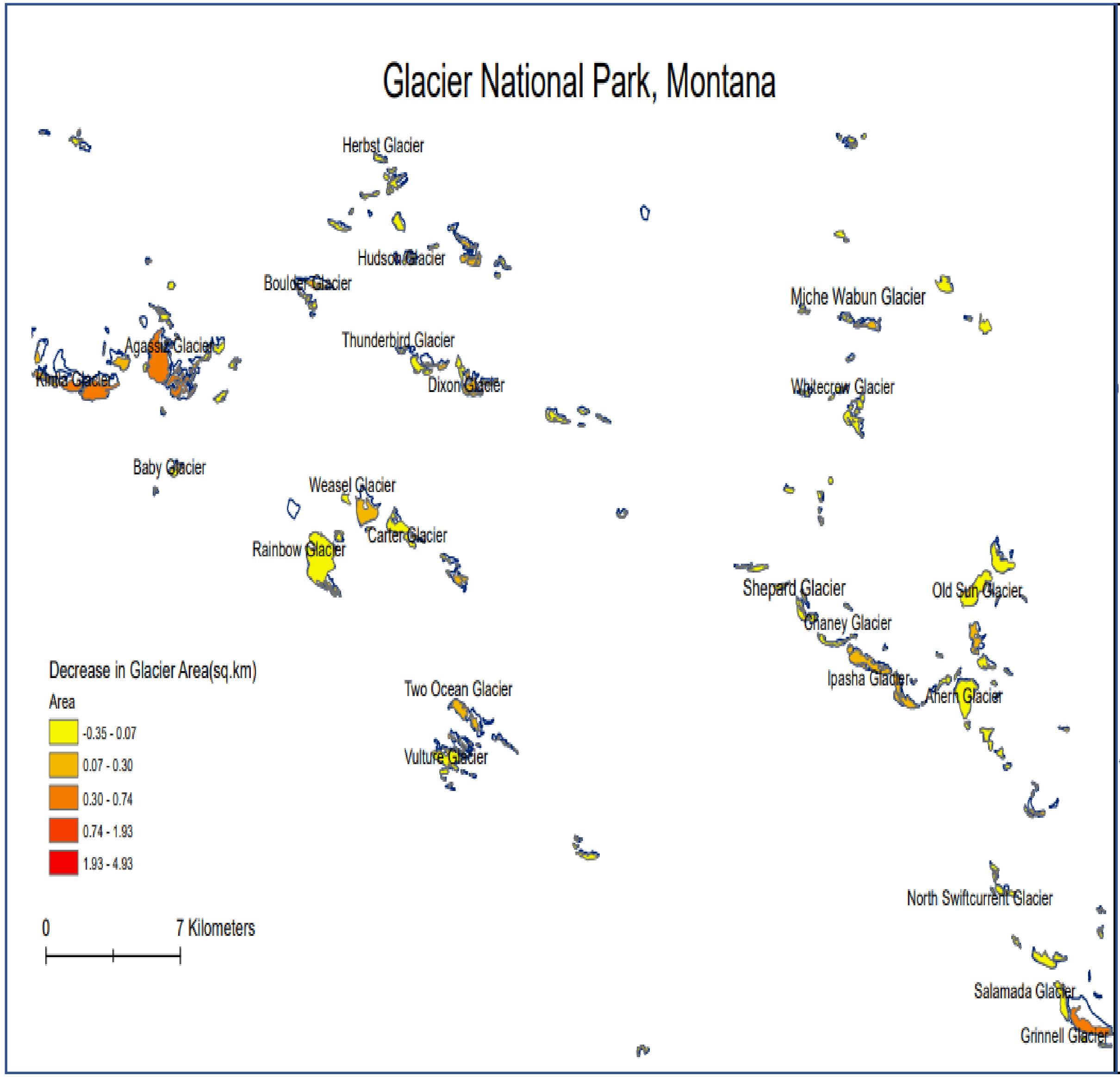
Mount Olympus, Washington

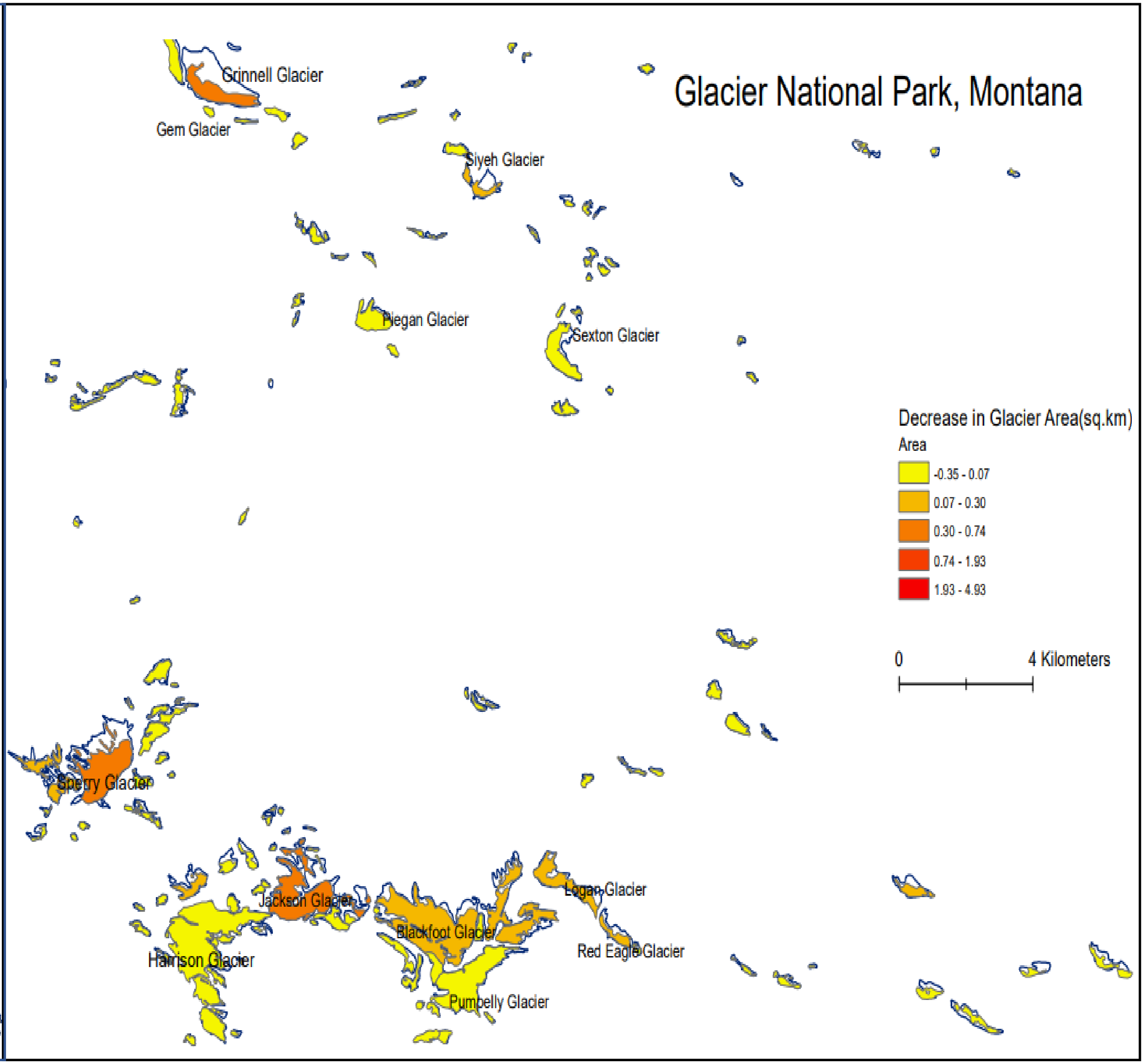


Mount Rainier, Washington

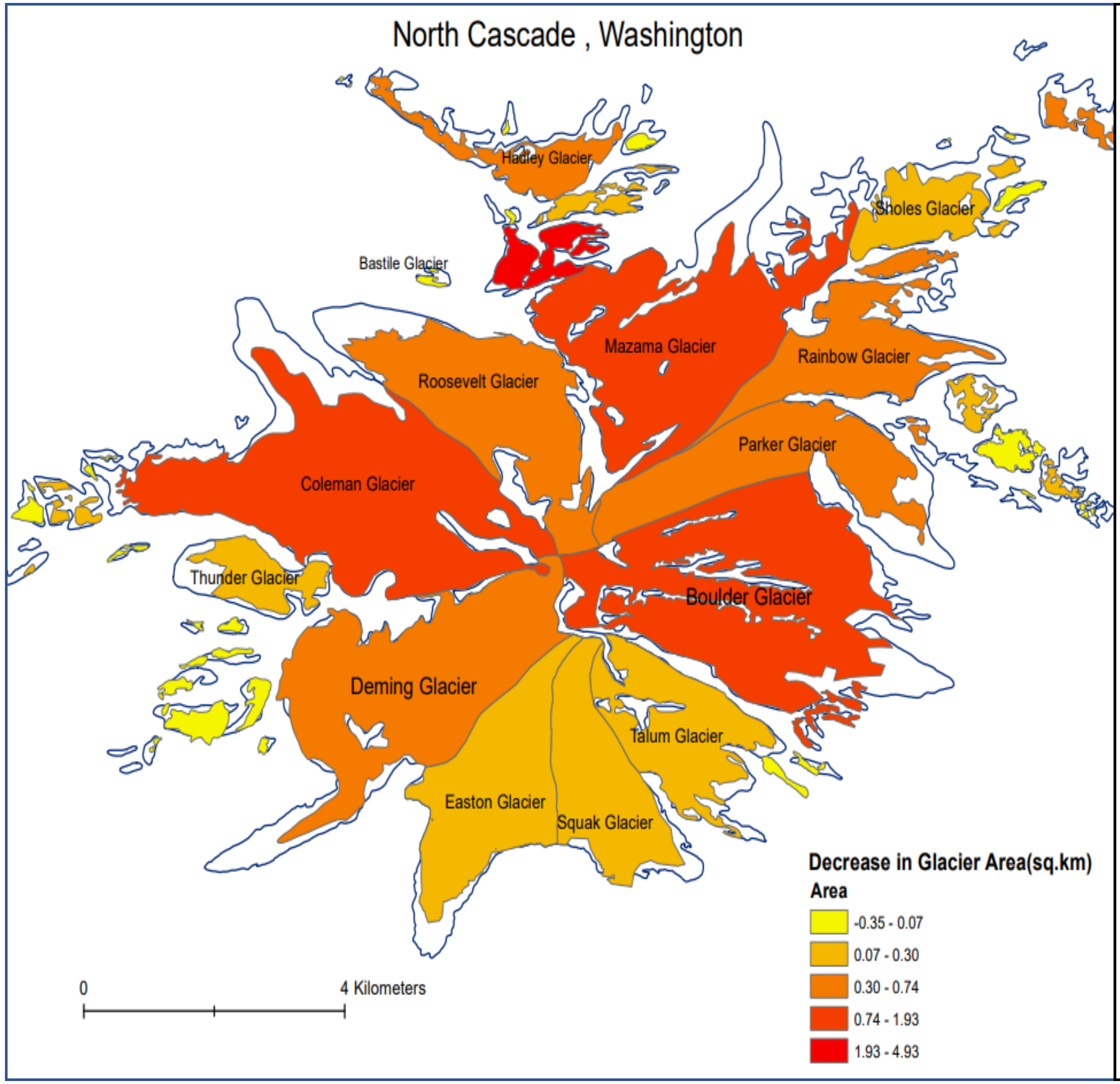


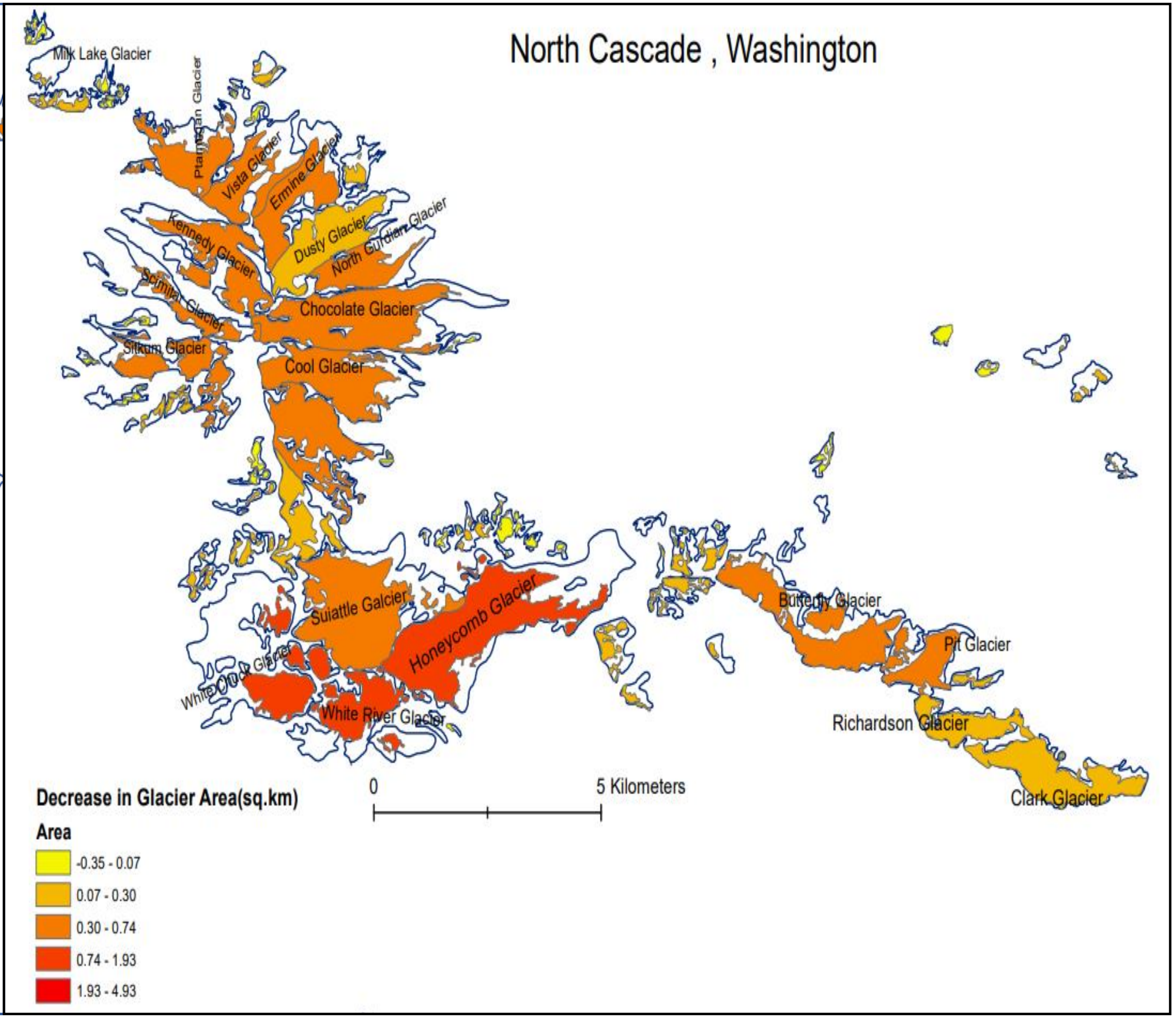
Glacier National Park



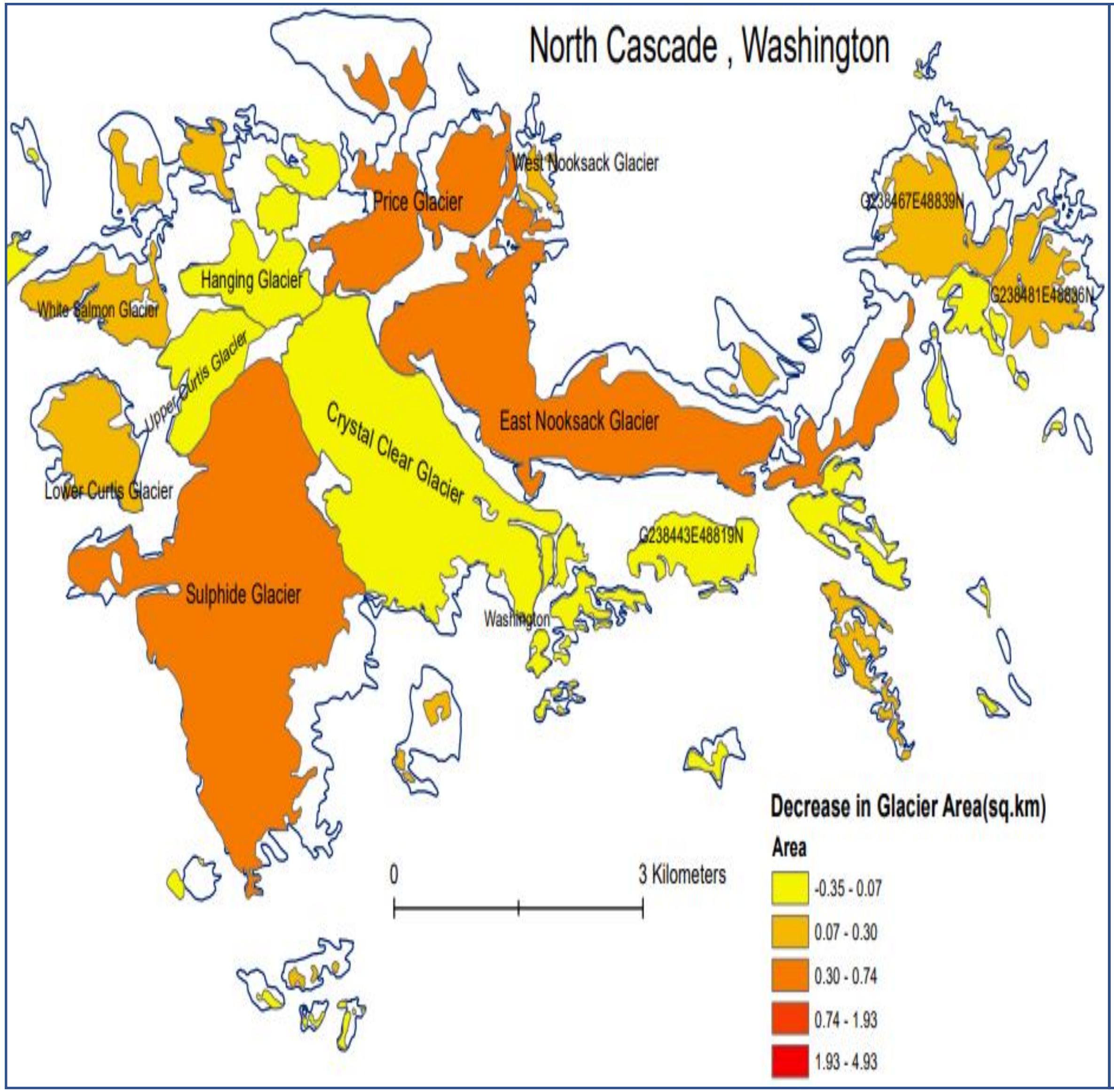


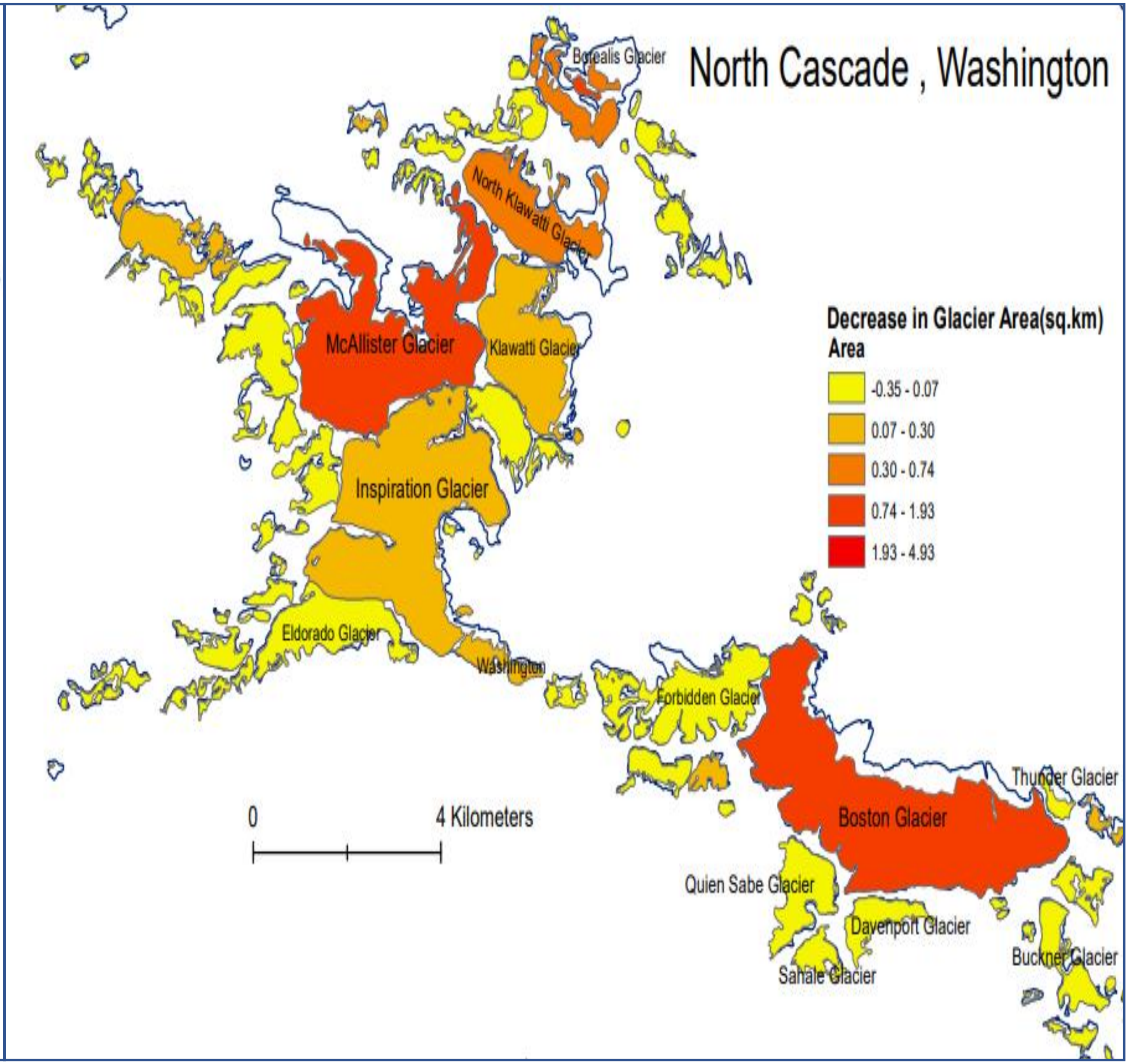
Major Glaciers in the North Cascade





Major Glaciers in the North Cascade





Conclusion

- Glaciers in the Western United States are experiencing significant melting and recession.

- Random Forest algorithms and Sentinel-2A images provide a more accurate and efficient means of monitoring changes in glaciers, compared to traditional methods.

- Overall, this research highlights the importance of continued monitoring and research on glacier health in the region.

Reference

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