International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 04 | Apr 2020 www.irjet.net p-ISSN: 2395-0072

STUDY OF GLACIAL LAKES LOCATED IN SIKKIM HIMALAYAN REGION USING SATELLITE DATA ON ARC GIS

MANISH KUMAR MISHRA[1], ANUBHA AGGARWAL[2] & ANUBHA MANDAL[3]

[1]M.Tech Scholar, Delhi Technological University
[2]DST Woman Scientist, Delhi Technological University
[3]Professor, Delhi Technological University, Delhi

Abstract: *Glaciers are one of the major features of our earth ecosystem. It constitutes a significant area of the earth. Glaciers serve as a good proxy to observe changes in the earth system. One such change is the retreating of glaciers and formation of glacial lakes. Formation of glacial lakes can be mainly attributed to the rise in the temperature. Many such lakes are formed or their area has been increased in the recent years in mountainous regions.*

In this study area of such glacial lakes in Sikkim Himalayan Region is studied for the period of 1970 to 2018 with the help Arc GIS. Landsat images are used for analysing the lakes and then their average is taken to calculate the area of the glacial lakes. Small lakes having area less than 0.2km^2 is neglected in this study. Meteorological conditions like temperature and rainfall and their possible effect on the glaciers and formation of glacial lakes is being studied. Changes of these lakes area with the change in the meteorological condition of the surrounding area are also studied. With the different features available in Arc GIS it becomes very helpful in calculating the area of the glacial lakes accurately. Changes in the area of glacial lakes in different years are also measured.

Keywords: *Glaciers, Glacial Lakes, GLOFs, Arc GIS*

1. INTRODUCTION

Glaciers are integral part of our earth's ecosystem. They cover 10% of the land mass of our planet earth. Glacier, continental ice sheets are storage of fresh water, and it corresponds to three-quarter of world's total fresh water resources. They are unique source of fresh water for agriculture, industry and domestic use, an important economic component. [1]

Glaciers always tempt researcher due to their special characteristics and their relationship with environmental condition of earth. Any change in environment is clearly indicated by them which make them so precious. Figure below shows the inventory of glaciers on our earth.

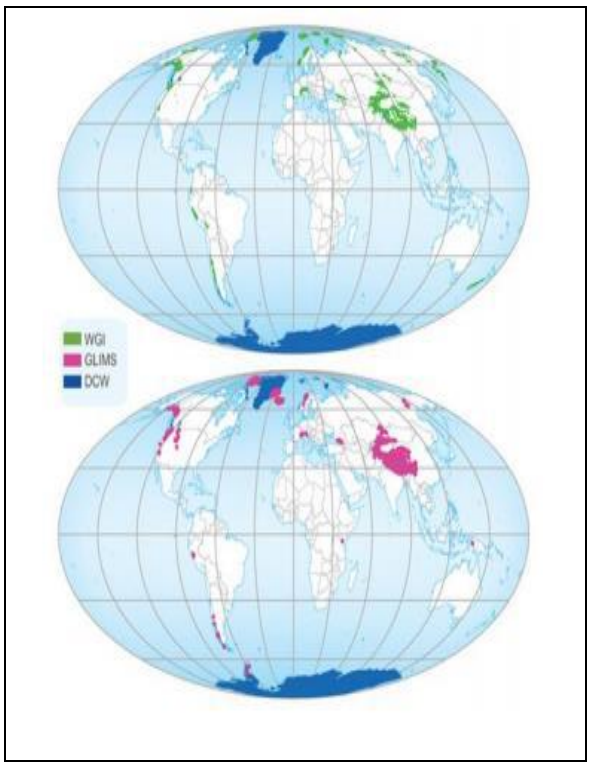

Fig-1: Glaciers on our planet Earth
(https://nsidc.org/data/glacier_inventory)

But, with the passing time these ice masses started to melt due to various changes in our atmospheric parameters like temperature, pressure etc. and start to form lakes in the glacier region, such lakes are known as glacial lakes. These glacial lakes contain huge amount of water but due to any natural or anthropogenic activities which can cause high intensity of vibrations makes the water of lakes to spill out and with this water huge amount of ice also comes to the valley region with it. This forms a flood like situation and such flood is known Glacial Lakes Outburst Floods (GLOFs).

1.1 GLOFs – A GLACIAL HAZARD

Glacial lakes are characterized as water mass present in an adequate sum and stretching out with a free surface in, under, next to, or potentially before an icy mass and beginning from icy mass exercises as well as withdrawing procedures of an ice sheet. IPCC in 2013 announced that change in temperature in Himalayan region by 5°C by 2100 the present situation of frosty ice and snow would diminish between 43 to 81 percent.[2] Himalayan icy masses could shrivel from its present degree of 500,000km^2 to 100,000km^2 by 2030 deserting a lot progressively frosty lake in future.

Break open or unexpected release of water alongside solids of the flora and fauna from such water bodies causes frigid lake upheaval floods in valley of downstream causing enormous harm to foundation (like dams, streets, neighbourhoods, ranches and so on), common assets (like woodlands) and living beings life. That's why these water bodies should be prioritized for their arrangement, development and weakness.

1.2 RS & GIS in GLOFs Study

With the coming of room borne innovations like-Remote Sensing (RS) and Geographic Information System (GIS) it is presently conceivable to screen such blocked off spots all through the year. With further increment of remote detecting stages with enhanced spatial and worldly goals help customary perception and superintendence of different characteristics of high ice sheets and icy mass parity.

2. STUDY REGION

The investigation site is Sikkim a state of Republic of India. Greater Himalaya, Eastern Himalaya and Middle Himalaya share their region in Sikkim. The state is decently rectangular fit as a fiddle with its longest dimension in N-S direction of about 112Km and its widest dimension in E-W direction of about 90Km. Sikkim is surrounded by some of the most noteworthy mountains. Towards west we see Nepal, as we move towards southern side we find Bhutan and then there is Tibetan Plateau when we move towards north eastern side of it. It is a land bolted Indian province. [3]

The peaks of the Himalaya in this region have its altitude going from as low as 300 m to as high as 8,600m above Mean Sea Level. Just about 66% of its landscape is unendingly secured with snow. This particular region of India is land of high peaks. [4]

Sikkim is remarkable in light of the different climatic belts in its overall region. It tends to be extensively partitioned into sub-tropical, alpine & temperate zone from north to south concerning the variety in altitude. The variety in elevation is to such an extent that one can travel through all the regions of different climatic condition inside 60 minutes. As precipitation happens consistently, the atmosphere is for the most part cold and sticky. Moreover, because of its nearness with Bay of Bengal the territory gets substantial precipitation. [5]

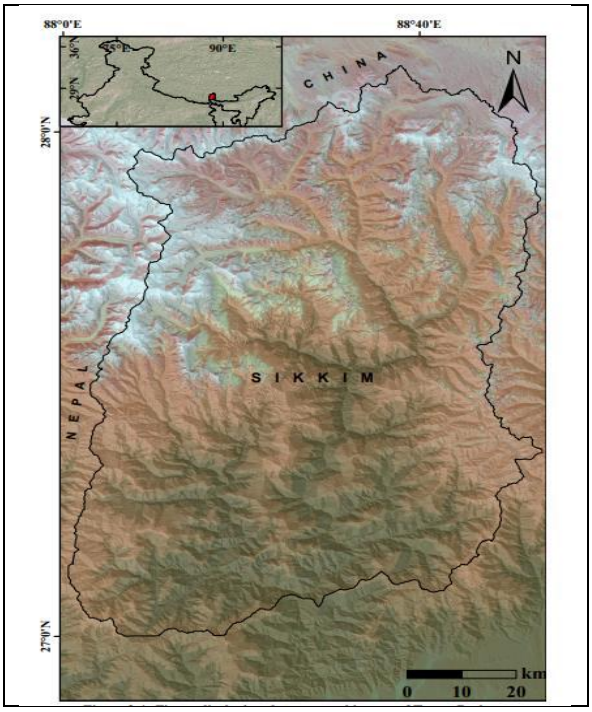

Fig-2: Study Area (Sikkim)
(https://www.mapsofindia.com/sikkim)

3. METHODOLOGY

3.1 DATA SOURCES

All the data are LANDSAT data that are used for this study. The LANDSAT data are collected from U.S. Land Survey (USGS) 'Earth Explorer' site. Mainly LANDSAT 7 and LANDSAT 8 data are used.

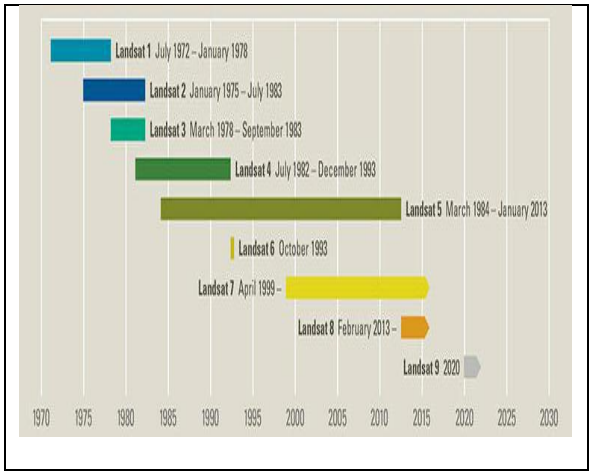

Fig-3: LANDSAT Missions
(https://en.wikipedia.org/wiki/Landsat_program)

3.1.1 LANDSAT 7

Landsat 7 is the seventh satellite of the Landsat program. Propelled on April 15, 1999, Landsat 7's essential objective is to revive the worldwide file of satellite photographs, giving cutting-edge and sans cloud pictures. The Landsat Program is overseen and worked by the USGS, and information from Landsat 7 is gathered and disseminated by the USGS. [6]

3.1.2 LANDSAT 8

LANDSAT 8 is a satellite started on February 11, 2013 for American Earth observation. It is the eighth Landsat satellite, the seventh to effectively achieve orbit. This is cooperation between NASA and USGS, originally called the Landsat Data Continuity Mission (LDCM). [7]

3.2 DATA COLLECTION

LANDSAT 8 and LANDSAT 7 are the sources of the pictures or information acquired, these pictures are downloaded using the USGS scheme. We should filter the information using months while downloading the picture and the following three requirements should be met:

- Minimum snow-: At the end of the ablation period, specify a time frame.
- Minimal clouds cloud coverage should be less than 10 percent of the data to be downloaded.
- Adequate contrast sensors are saturated in the visible bands, therefore low gain settings are suggested in those bands.

2000, 2005, 2010, 2012, 2016, 2017 and 2018 data are downloaded. The 2016, 2017 and 2018 data are from Landsat 8, while all other year data are from LANDSAT 7.

3.3 DATA PROCESSING

Data collected from LANDSAT 7 and LANDSAT 8 is processed in the following manner.

i. Adding data to Arc MAP
ii. Creating false colour composite

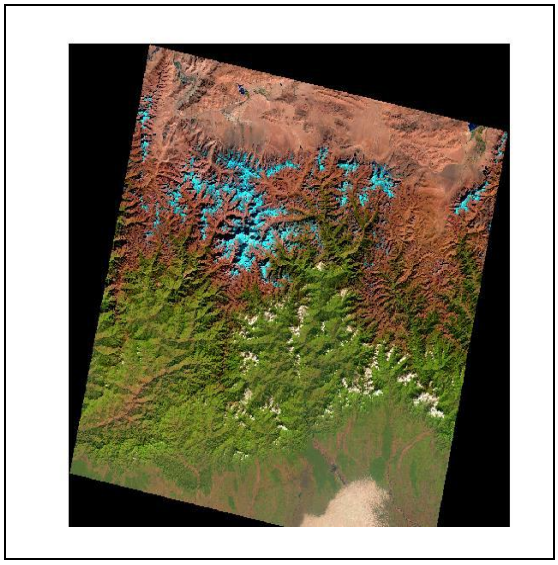

Fig-4: Face Colour Composite

iii. Finding Normalized Difference water ratio

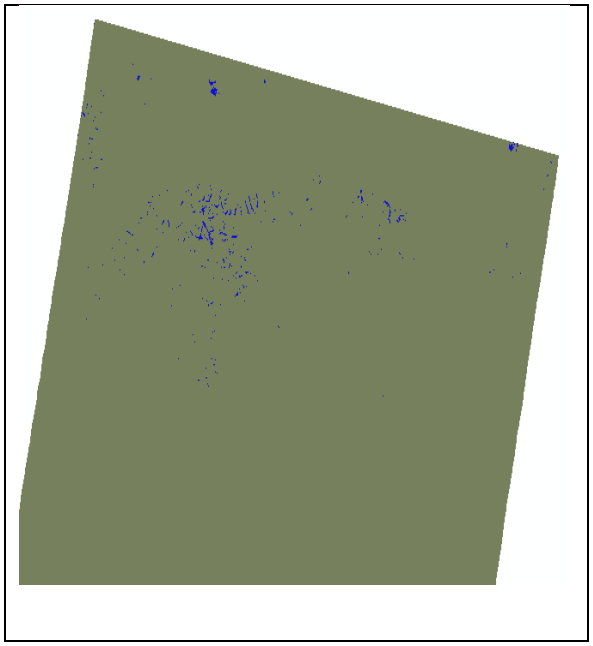

Fig-5: NDWI

iv. Finding threshold for lakes

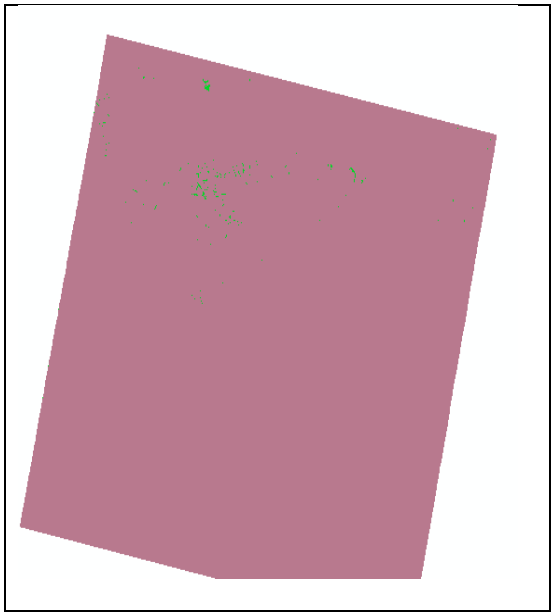

Fig-6: Threshold Image

v. Filtering image

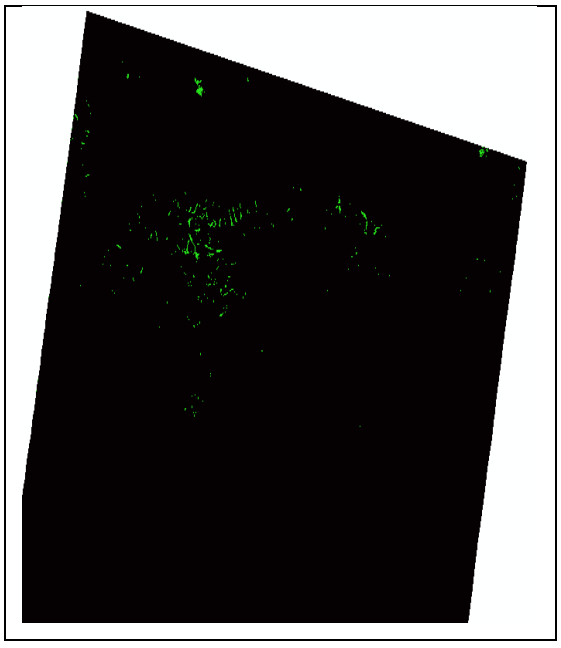

Fig-7: Filtered Image

vi. Converting Raster to Vector

vii. Extraction of final data

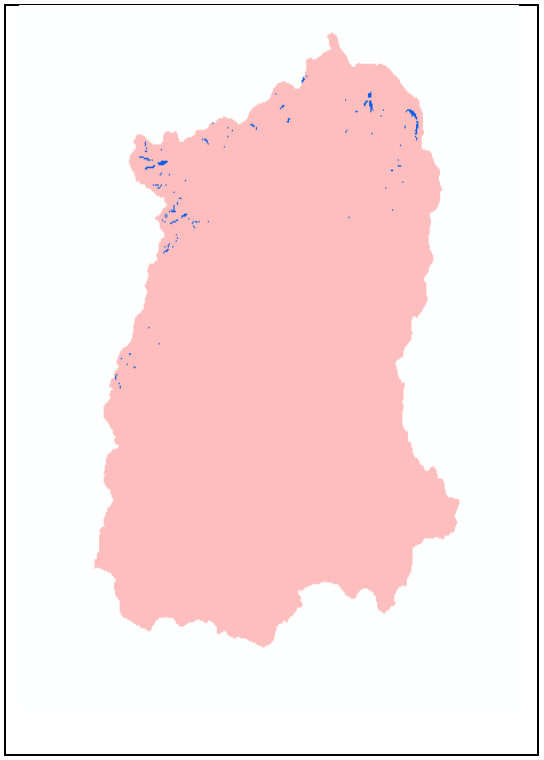

Fig-8: Lakes in Sikkim

viii. Calculation of area

Fig-9: Lakes Area > 0.2Km²

3.3 ANALYSIS OF METEOROLOGICAL DATA

3.4.1 Temperature Variation

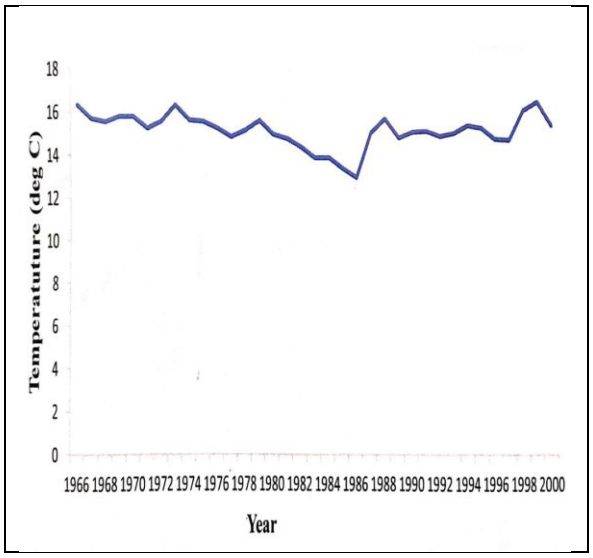

Fig-10: Annual Temperature Variation Graph from 1966-2000

3.4.2 Rainfall Analysis

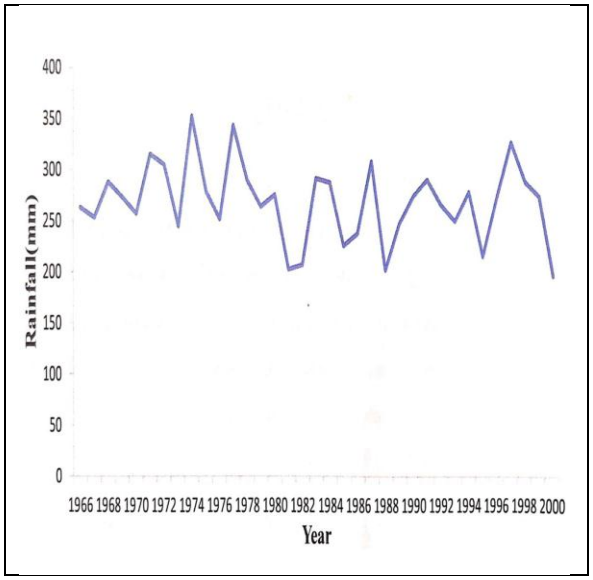

Fig-11: Annual Average Rainfall Variation Graph from 1966-2000

4. RESULTS AND DISCUSSIONS

This study highlights the assessment of lakes present in the Sikkim Himalayan region for possible inferences of global climate change impacts in high mountains like the Himalaya. The study has been done with the help of remote sensing data obtained from Landsat Thematic Mapper and Indian Remote Sensing (IRS) satellite images. Data has been obtained from USGS (United States Geological Survey) system named Earth explorer for the year 2000, 2005, 2010, 2012, 2016, 2017 and 2018. Area for all the years has been calculated by performing various tasks in ArcGIS.

The total glacial lakes area was observed as 8.49Km^2 in 2000, 8.91Km^2 in 2005, 9.95 Km^2 in 2010, 12.78 Km^2 in 2012, 17.2 Km^2 in 2016, 18.9 km^2 in 2017 and 19.6 Km^2 in 2018. With the area calculated for all the years it is observed that with the passage of time area of glacial lakes in the Sikkim Himalayan region is continuously increasing. The area coverage of glacial lakes increased during the period of 2000 to 2018. The overall area of glacial lakes in the Sikkim region was 31.24 ± 2.36 km^2 as reported by Aparna et.al. (2018) till 2017. The percentage change in the area of glacial lakes is 3.77% during 2017 to 2018. Glacial lakes area is increasing in size year by year because the falling snow is not able to replace the melted ice. Since glacial lakes are one of the most reliable climate indicators which indicated the change in the climate could be due to anthropogenic activities.

5. CONCLUSION

Area of glacial lakes in the Sikkim Himalayan region was calculated for years 2000, 2005, 2010, 2012, 2016, 2017 and 2018. Landsat data was used to carry out the study. Automatic delineation methods were used to derive the results. As per the results of the study, the region has shown to have gain of 11.11Km^2 of area from 2000 till 2018. Results calculated might vary with actual situation of depletion of area. The variation might occur as per resolution problem in data, presence of debris presents in the glacial lakes, the shadows of the mountains and cloud cover (which could not be classified very efficiently).

Since temperature and rainfall play a very significant role in changing in climatic conditions and these climatic changes are responsible for increase in area of glacial lakes. So, temperature and rainfall data taken from IMD website was analysed for years 1966-2000. The average value of temperature from 1966-2000 was found to be 15.1°C whereas the average value of rainfall from 1966-2000 was found to be 269.22mm. The observed value of temperature was found to be very less as compared to temperature values now days, “Industrial revolution” is mentioned as the main cause of this rise in average temperature in many researches done earlier. [9]

According to the results given out by World Glacier Monitoring Service, the UN Environment programme declared that around the world glaciers are melting rapidly which in turn cause in increase in the size of glacial lakes. Mainly recent research had revealed that the average rate of formation in the area of glacial lakes had increased and it is definitely a major cause of concern for whole world. It had been observed in the research that glacial lakes area have increased over the past centuries. The prime reason for this increase in area of glacial lakes is rapid industrialisation which in turn has caused global warming is the prime culprit of formation of these glacial lakes.

Formation of these glacial lakes and increase in the area of these glacial lakes can cause the stream and rivers to overflow and also a huge deposition of the melted water is getting accumulated in the mountainous region, which will outburst when this melted water will cross its certain limit. These GLOFs are very dangerous and can occur at any time in future.

This study is a kind of warning for all of us to anyhow control the cause of global warming, so as to preserve the nature and control the adverse climatic changes in the atmosphere. Government as well as individual should work at their levels to control pollution which is directly or indirectly responsible for global warming.

6. REFERENCES

1) UNEP, "Global glacier changes: Facts and Figures".
2) IPCC, "Climate change 2013: 2013: The physical science basis. In Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change".
3) http://www.sikkimtourism.gov.in/Webforms/General/SikkimAtAGlance/Mountains.aspx
4) https://www.incredibleindia.org/content/incredibleindia/en/destinations/states/sikkim.html
5) Govt. Of Sikkim, "The Sikkim State Action Plan on Climate Change Report".
6) https://www.usgs.gov/landresources/nli/landsat/landsat7?qtscience_support_pagerelated_con=0#qtscience_support_page _related_con
7) https://www.usgs.gov/landresources/nli/landsat/landsat8?qtscience_support_pagerelated_con=0#qtscience_support_page _related_con
8) Aparna Shukla, Purushottam K. Garg, and Smriti Srivastava, "Evolution of Glacial and High-Altitude Lakes in the Sikkim, Eastern Himalaya Over the Past Four Decades (1975–2017)".
9) http://www.imdsikkim.gov.in/