

## Lesson Plan: Himalayan Glaciers: Climate Change in Bhutan

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As a **High School** or **Undergraduate Geography** or **Earth Sciences** teacher, you can use this set of computer-based tools to teach about **landforms**. This lesson plan focuses on **glaciers, glacier lakes** and climate change induced **glacier lake outburst floods (GLOFs)**.

Use this lesson plan to teach your students about the **formation and characteristics of glaciers, types of glaciers**, and the **effect of climate change on glaciers**. Global warming is causing glaciers to melt rapidly, resulting in larger volumes of water accumulating in glacier lakes. In time, these glacier lakes burst their **morainic** banks resulting in GLOFs that cause widespread damage downstream of the glaciers. Globally, there are many **potential hotspots for GLOFs**. This lesson plan includes resources to show how the Himalayan country of **Bhutan** has been affected by climate change induced GLOFs and their methods of adaptation to avert disaster.

Thus, the use of this lesson plan allows you to integrate the teaching of a climate science topic with a core topic in **Geography** or **Earth Sciences**.

Use this lesson plan to help your students find answers to:

1. What are glaciers? How are they formed?
2. Describe the components of a glacier.
3. What are the different types of glaciers?
4. How are glaciers affected by climate change?
5. Describe the threat posed by GLOFs.

[About the Lesson Plan](#)

**Grade Level:** High School, Undergraduate

**Discipline:** Geography, Earth Sciences

**Topic(s) in Discipline:** Glaciers, Glacial Landforms, Glacier Lakes, Moraine, Avalanches, Ice Shelves, Glacier Snouts, Snowmelt, Glacier Lake Outburst Floods (GLOFs), Ablation, Accumulation, End Moraine, Terminal Moraine

**Climate Topic:** Climate and the Lithosphere, Climate and the Cryosphere, Climate and the Anthroposphere

**Location:** Global, Peru, India, Bhutan

**Access:** Online

**Language(s):** English

**Approximate Time Required:** 50-60 min

# 1 Contents

## 1. Reading (10 min)

A basic introductory text to different types of landforms.

This can be found at:

<http://www.edu.pe.ca/southernkings/landforms.htm>

## 2. Reading (20-30 min)

A resource that describes what glaciers are and explores many aspects of glaciers.

This can be accessed at:

<https://nsidc.org/cryosphere/glaciers>

## 3. Video (~6 min)

A video that describes the danger posed by glacier lakes in Bhutan and shows how the country is coping with the threat of GLOFs due to climate change.

This can be accessed at:

[https://www.youtube.com/watch?time\\_continue=21&v=BexXgQakves](https://www.youtube.com/watch?time_continue=21&v=BexXgQakves) (up to 5.45 min)

#### 4. Classroom/Laboratory Activity (15 min)

A simulation tool to show the growth and shrinkage of glaciers with climate related variations in mountain snowfall and temperatures. This tool is available in several languages.

This can be accessed at:

<https://phet.colorado.edu/en/simulation/glaciers>

#### 5. Suggested questions/assignments for learning evaluation

- What are glaciers? How are they formed?
- Describe the components of a glacier.
- What are the different types of glaciers found?
- How do glaciers affect the land on which they are formed?
- How are glaciers affected by climate change?
- Describe the threat posed by GLOFs in mountainous regions of glaciation.

## 2 Step-by-step User Guide

Here is a step-by-step guide to using this lesson plan in the classroom/laboratory. We have suggested these steps as a possible plan of action. You may customize the lesson plan according to your preferences and requirements.

### 1. Topic introduction and discussion

Use the reading, '[Landforms](#)' by Southern Kings Consolidated School, Prince Edward Island, Canada, to define landforms, different types and characteristics. Use the links provided in the reading to introduce your students to landforms such as valleys, plateaus, mountains, plains, hills, loess, and glaciers. Click on 'Games' at the top of the page to enable your students to test their knowledge about basic physical features of the earth.

This can be accessed at:

<http://www.edu.pe.ca/southernkings/landforms.htm>

### 2. Discuss further

Use this reading, '[All About Glaciers](#)' by National Snow & Ice Data Center, to teach your students about different aspects of glaciers. Use the tabs on the left side of the text box to navigate to different topics like how glaciers are formed, the components of a glacier, and the types of glaciers. Discuss with your students how glaciers affect people and what the dangers associated with them are. Finally, navigate to the section on 'glaciers and climate change' to explain to your students how warming temperatures have resulted in rapid melting of glaciers. Discuss how retreating glaciers have been documented using satellite imagery in various regions of the Himalayas, for example, the Gangotri Glacier. Explain how glacier lakes are formed due to meltwater from glaciers that gets accumulated behind fragile morainic banks at the snout of the glacier. Describe how increased snowmelt from glaciers greatly raises the level of accumulated water in glacial lakes, adding pressure to the morainic banks that are vulnerable to breaking down and causing GLOFs. Use the text to discuss the devastation caused by recent cases of GLOFs in Huaraz, Peru; Uttarakhand, India; and Lemthang Tsho, Bhutan.

This can be accessed at:

<https://nsidc.org/cryosphere/glaciers>

### 3. Extend the understanding

Use the video, '[GEF -Bhutan: Silent Tsunami](#)' (up to 5.45 min) by Global Environment Facility to explain to your students the perceived threat of GLOFs for a largely mountainous Himalayan country like Bhutan. Use the tool to discuss past occurrences of GLOFs and the possible destruction of resources, infrastructure and livelihoods due to sudden GLOFs in the future. Use the video to discuss the urgent need for preemptive action

against the buildup of glacier lake meltwater levels and explain how Bhutan has enlisted the help of international organizations to adapt to this need for action against the effects of climate change. Explain the disaster management strategies of installing early-warning systems like water-level sensors in remote glacial locations and the early release of water from the glacier lakes that show dangerous levels of snowmelt accumulation.

This can be accessed at:

[https://www.youtube.com/watch?time\\_continue=21&v=BexXgQakves](https://www.youtube.com/watch?time_continue=21&v=BexXgQakves)

#### 4. Classroom/Laboratory Activity

Use this simulation, '[Glaciers](#)' by PhET Interactive Simulations, University of Colorado, Boulder, to explore how environmental conditions such as temperature and precipitation affect the thickness, velocity and the glacial mass budget of glaciers.

NOTE: This simulation is available in several languages.

Encourage your students to vary these conditions and measure changes in the glacier using the instruments from the built-in toolbox. Use the in-built graphs to enable your students to visualize changes in glacier-length over time, the equilibrium line altitude against time, the glacial budget against elevation and air temperature against elevation. Use the sample learning goals to encourage discussion on the given points and enhance student understanding of the topic of impact of temperature and precipitation on the dynamics and nature of glaciers. Discuss how this is related to real-life scenarios of effect of climate change induced variations in global temperatures and precipitation patterns on glaciation globally.

Optional: Use the 'Teacher-submitted Activities' under the tab 'For Teachers' to explore more activities using this simulation. This will require a login/registration to access the teacher submitted activity plans.

This can be accessed at:

<https://phet.colorado.edu/en/simulation/glaciers>

## 5. Questions/Assignments

Use the tools and the concepts learned so far to discuss and determine answers to the following questions:

- What are glaciers? How are they formed?
- Describe the components of a glacier.
- What are the different types of glaciers found?
- How do glaciers affect the land on which they are formed?
- How are glaciers affected by climate change?
- Describe the threat posed by GLOFs in mountainous regions of glaciation.

## 3 Learning Outcomes

The tools in this lesson plan will enable students to:

- define what are glaciers and describe their components
- describe the different types of glaciers
- understand how glaciers are affected by climate change
- discuss the dangers posed by glaciers and the disaster management strategies employed to mitigate them

## 4 Additional Resources

If you or your students would like to explore the topic further, these additional resources will be useful.

### 1. Reading

A policy document, 'Global Lake Outburst Flood' by the Department of Disaster Management, Royal Government of Bhutan that describes the strategies employed in Bhutan to reduce the risk of GLOFs in susceptible areas.

This can be accessed at:

<http://www.ddm.gov.bt/glof>

### 2. Reading

A resource that gives details of the UNDP-supported project, 'Reducing Climate Change-induced Risks from Glacial Lake Outburst Floods in Bhutan' by the Royal Government of Bhutan.

This can be accessed at:

<https://www.adaptation-undp.org/projects/lDCF-glof-bhutan>

### 3. Reading

An article, 'First global analysis of the societal impacts of glacier floods' by Sam Inglis, GlacierHub, that describes the results of a study on the impacts of GLOFs on people world-wide.



This can be accessed at:

<http://glacierhub.org/2016/07/28/first-global-analysis-of-the-societal-impacts-of-glacier-floods/>

## 5 Credits/Copyrights

All the teaching tools in our collated list are owned by the corresponding creators/authors/organizations as listed on their websites. Please view the individual copyright and

ownership details for each tool by following the individual links provided.

We have selected and analyzed the tools that align with the overall objective of our project and have provided the corresponding links. We do not claim ownership of or responsibility/liability for any of the listed tools.

### 1. Reading; “Landforms”

By [Southern Kings Consolidated School](#), Prince Edward Island, Canada.

### 2. Reading; “All About Glaciers”

By [National Snow & Ice Data Center \(NSIC\)](#).

### 3. Video; “GEF -Bhutan: Silent Tsunami”

By the [Global Environment Facility \(GEF\)](#).

#### 4. Classroom/Laboratory Activity; “Glaciers”

Developed by [PhET Interactive Simulations](#), University of Colorado, Boulder.

#### 5. Additional Resources

A policy document, ‘Global Lake Outburst Flood’ by the [Department of Disaster Management](#), Royal Government of Bhutan.

A reading, ‘Reducing Climate Change-induced Risks from Glacial Lake Outburst Floods in Bhutan’ by the Royal Government of Bhutan. Supported by the [United Nations Development Programme \(UNDP\)](#).

An article, ‘First global analysis of the societal impacts of glacier floods’ by Sam Inglis, [GlacierHub](#).