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**Date: 07/04/2022**

**CERTIFICATE**

This is to certify that the thesis entitled **“Glacier Inventory and Hazard Zonation of Moraine Dammed Lakes in Eastern Himalayan Region”** is submitted by **Mrs. Vanya Bajpai** (FOS/1890), to the Department of Geography, Faculty of Science, The Maharaja Sayajirao University of Baroda in partial fulfillment of the requirements for the award of the degree of Doctor of Philosophy in Geography. The thesis has not been submitted so far in part or in full, for any other degree or diploma to any university/institution.

**(Prof. Rolee Kanchan)**  
Supervisor

**Head**  
Department of Geography

## **CERTIFICATE FOR ANTI PLAGIARISM**

This is to certify that the Ph.D. Thesis entitled “**Glacier Inventory and Hazard Zonation of Moraine Dammed Lakes in Eastern Himalayan Region**” submitted by **Mrs. Vanya Bajpai** (FOS/1890) has been checked for anti-plagiarism test by iThenticate Software provided by the M. S. University of Baroda. After checking, it is found that only 5% of similarity which is below the allowable plagiarism notified by the University Grants Commission. This research work has been carried out by **Mrs. Vanya Bajpai** under my supervision, Department of Geography, Faculty of Science, The M. S. University of Baroda.

**Prof. Rolee Kanchan**

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# Glacier Inventory and Hazard Zonation of Morain...

By: Vanya Bajpai

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CONCEPTUAL FRAMEWORK 1.1:- General Description of Glacier  
Glaciers are typically thought of as a mass of ice that moves down a slope steadily. Out of ice crystals, water and rock debris, ice is the most vital component of the glacier. Sugden and John (1976) classified glaciers into three groups based on their morphological characteristics which were bounded by topography viz. glacier, ice caps and ice sheets. When the underlying topography is completely covered by ice, ice sheet and ice cap develop and the glacier flow is unaffected by the geomorphology of the region. Valley glaciers, cirque glaciers and ice fields, on the other hand, are glaciers whose movement is influenced by the structure of the valley and driven by the topography of the region. As a result, valley glaciers dominate the Himalayas. Valley glaciers may develop in an ice field or cirque built on the comparatively gradual slope of high mountainous terraces and glaciers therefore flow from ice fields to valleys. Figure 1.1: Typical Diagram of Valley Glacier Source: Anil V. Kulkarni (Unpublished PhD. Thesis, 1995)  
The temperature of the ice mass can also be used to categorize glaciers. This is due to the fact that temperature has a significant impact on their morphological behaviours. This consideration splits glaciers into two types: temperate and cold. Since, Himalayan glaciers are temperate in nature, only those would be discussed here (Embleton and King, 1975). Temperate glaciers, on the other hand, are normally at the pressure melting point in their thickness, except for the highest few metres, which can become briefly colder in winter. In addition to this, melting also happens at the base of a temperate glacier due to the pressure melting point's reverse temperature gradient. Figure 1.1 depicts the usual outline of a valley glacier as well as other attributes such as the glacier boundary, equilibrium line, ice divide line, active and inactive ice, moraines and moraine-dammed lakes. Present Distribution of Glaciers  
Glacial ice, which includes glaciers, ice sheets and the ice fields of Greenland and Antarctica, occupies 10% of the Earth's land mass. Glaciers cover approximately 16 million square kilometers (5.8 million square miles). Glaciers contain about 69% of the world's fresh water. Glaciers occupied about 32% of the entire surface area at the peak of the last ice age which started around the 14th century and lasted to the mid-19th century. It is estimated that, if all land ice melts, global sea level will increase by around 70 metres (230 feet) (NSIDC, 2020). Outside of Antarctica (13.5 million square kilometers) and Greenland (2 million square kilometers), the Himalaya has the world's largest glacier belt, covering 15% of the land area (Ashish, et al., 2006) (Benn & Evans, 1998).  
1.2:- Origin of the Research Problem  
The direct source of knowledge on climate change is provided by the glaciers. (Nesje and Dahl, 2000). Mountain glaciers, in particular, are extremely susceptible to temperature and precipitation variations. They vary their mass balances, which impact their sizes, in response to minute variations in local climate (Oerlemans, 2005) and this can be used as a climate proxy. As a result, paleo-climatic assumptions are frequently relied on the extent of ancient mountain glaciers are determined by the location of their moraines (Refsnider et al., 2007). In the Himalayan Region, where the present glaciers are located, glacier lakes of all sizes and shapes were extensively spread. The fast accumulation of melt water in most of the moraine-dammed lakes in the basin has come from glacier retreat during the last decade. It has boosted their potential energy and decreased the damming material's shear strength (Bajracharya and Mool, 2009). The loose-moraine dam will



## THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA

### PUBLICATION CERTIFICATE

**Name of Ph.D. Supervisor** Prof.ROLEE KANCHAN

#### **Published Articles/Papers in Journals**

Sr No.	Author(s)	Paper Title	Journal Name & ISSN & Volume No.	Published Year	DOI	Index in Scopus/UGC CARE/Clarivate	Document Submitted?
1	Vanya Bajpai, Rolee Kanchan	ELEVATION BASED COMPARATIVE ANALYSIS OF GLACIERS OF SIKKIM AND BHUTAN USING REMOTE SENSING DATA	Journal Name: Annals of the National Association of Geographers India, ISSN: 0970972X , Volume No.: 41	1-6-2021	<a href="https://doi.org/10.3238/ATNAGI.2021.41.02.3">https://doi.org/10.3238/ATNAGI.2021.41.02.3</a>	In Scopus: Yes, In UGC CARE: Yes, In Clarivate: Yes	Submitted
2	Shweta Khandelwal, Rolee Kanchan	An Investigation into spatial accessibility of Primary Health Centers in Ahmedabad District, Gujarat , India.	Journal Name: Annals of the National Association of Geographers India, ISSN: 0970972X, Volume No.: 402	1-12-2020		In Scopus: Yes, In UGC CARE: Yes, In Clarivate: Yes	Submitted
3	Sukanta Kumar Saha, Tathagata Ghosh, Rolee Kanchan	Application of Geospatial Technique in Identification of Cropping Pattern and Cropping Intensity in Central Gujarat, India	Journal Name: Transactions, Institute of Indian Geographers, ISSN: 09709851, Volume No.: 422	1-7-2020		In Scopus: Yes, In UGC CARE: Yes, In Clarivate: Yes	Submitted
4	Mukesh Kumar Bind and Rolee Kanchan	Assessing Groundwater Quality Using Geospatial Technology: A Case Study of Surat District, Gujarat, India	Journal Name: Journal of Global Resources , ISSN: 23953160 , Volume No.: 602	1-7-2020	<a href="https://doi.org/10.46587/JGR.2020.v06i02.001">doi.org/10.46587/JGR.2020.v06i02.001</a>	In Scopus: Yes, In UGC CARE: Yes, In Clarivate: Yes	Submitted

5	Tathagata Ghosh, Rolee Kanchan	Seasonal Pattern of Groundwater Geochemistry Using Multivariate Statistical Technique in the Bengal Alluvial Tract, India.	Journal Name: Purakala , ISSN: 09712143 , Volume No.: 3115	1-4-2020	In Scopus: Yes, In UGC CARE: Yes, In Clarivate: Yes	Submitted
6	Somnath Saha, Sukanta Kumar Saha, Tathagata Ghosh, Rolee Kanchan	An Evaluation of Sub surface Water Quality Around Bharuch-Surat Industrial Region, Gujarat, India	Journal Name: Annals of the National Association of Geographers India, ISSN: 0970972X, Volume No.: 382	1-12-2018	In Scopus: Yes, In UGC CARE: Yes, In Clarivate: Yes	Submitted
7	Rolee Kanchan, Tathagatha Ghosh, Somnath Saha, Sukanta Kumar Saha	Physio-chemical Appraisal of Sub-surface water characteristics in the coastal urban industrial belt of Mainland Gujarat, India	Journal Name: Advances in Urban Studies in India ed V. K. Tripathi ,	1-10-2018	In Scopus: No, In UGC CARE: No, In Clarivate: No	Submitted
8	Vanya Bajpai, Rolee Kanchan, I.M. Bahuguna	Geospatial Technique based Glacial Inventory of Bhutan Himalaya, Bhutan	Journal Name: International Research Journal of Environmental Science, ISSN: 23191414 , Volume No.: 59	1-9-2016	In Scopus: Yes, In UGC CARE: Yes, In Clarivate: Yes	Submitted
9	Tathagatha Ghosh, Rolee Kanchan	Aquifer vulnerability assessment in the Bengal alluvial tract, India, using GIS based DRASTIC model	Journal Name: Model. Earth Syst. Environ, ISSN: 2362-6211	1-8-2016	In Scopus: No, In UGC CARE: No, In Clarivate: No	Submitted
10	Rolee Kanchan, Chandam Chandabadani Devi	Status of human Health in Industrial Neighbourhood: A study of Golden Corridor, Vadodara, Gujarat	Journal Name: Journal of Environmental Science and Engineering , ISSN: 0367827X	1-4-2016	In Scopus: No, In UGC CARE: No, In Clarivate: No	Submitted

11	Vanya Bajpai, Rolee Kanchan, A.K.Sharma	Study of Glacier Inventory For Tista River Basin Using Remote Sensing and GIS Techniques	Journal Name: The Deccan Geographer , ISSN: 00117269, Volume No.: 531	1-6-2015	In Scopus: Yes, In UGC CARE: Yes, In Clarivate: Yes	Submitted
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### Paper Presented in Conference/Symposia/Seminar

Sr No.	Authors	Paper Title	Paper Theme	Organising Body	Date of Publication	Documents Submitted?
1	Rolee Kanchan		21st Century Challenges of Agriculture, Health and Development in India with Special Focus on Tribal Areas	Department of general and Applied Geography, Dr. HariSingh Gour Vishwavidalaya (Central University), Sagar	28-12-2019	Submitted
2	Rolee Kanchan, Tayhagatha Ghosh, Somnath Saha, Sukanta Kumar Saha	Regionalization of Seasonal Cropping Pattern using IRS LISS-III Images in Anand District of Gujarat, India	12th World Congress of RSAI	RSAl	30-5-2018	Submitted
3	Rolee Kanchan, Vanya Bajpai	A Proximity Syudy of Glaciers to the Human Settlements in Sikkim Himalayas	Sustainable Earth Resource Development	Indian Society of Remote Sensing and Indian Society of Geomatics, Dehradun	7-12-2016	Submitted
4	Sukanta Kumar Saha, Rolee Kanchan	An Investigation of Landuse/land Cover Changes Using Geospatial Technology:A case Study of Bharuch District	9th International Geographical Union (IGU) Conference, Landuse change, climate extremes and disaster risk reduction	Shaheed Bhagat Singh College, University of Delhi,	18-3-2016	Submitted

I Undersign, agree that all submitted information in above format is true as per my knowledge and belief.

Prof.ROLEE KANCHAN