

# GLACIER SHRINKAGE AND ENVIRONMENT; A REVIEW

Noor Ul Ane

**Abstract**— this study was conducted in the form of a term review paper as M.Phil. Scholar at Department of Zoology, University of Gujrat, Pakistan during 2015. The data of last three decades concerning glacier shrinkage and its impacts was compiled through a thorough review of thirty research papers, review papers and articles published in journals of national and international repute. The status of different glaciers in different continents of the world except Australia was estimated. Common factors in all the continents included continuously rising temperature and glacier disappearance in past few decades. The factors affecting glacier shrinkage like global warming and climate change had been pointed out. Possible impacts of glacial shrinkage included floods, rising sea level and water shortages. It was concluded that glacier shrinkage is occurring globally and it may lead to catastrophic events if it occurred continuously.

**Index Terms**— Status of glaciers, glacier shrinkage, factors, impacts.

## 1 INTRODUCTION

**H**UMAN activities on planet earth are causing long lasting damages. Growing industrialization at the cost of natural assets is bringing unpredictable changes. One such change atmospheric temperature. Almost in every part of earth temperature is increasing at about 0.3-0.5°C per decade from 1900 to 2005 [1]. Average global temperatures are expected to rise 1.4-5.8°C by the end of the 21st century. A clear indication of rising temperature can be detected from mountains. Changes in climatic conditions are directly affecting the high mountainous areas and are doing so at a much faster rate [2].

Climatic change due to global warming has direct effect on mountains. High temperature on mountains cause melting of ice while high temperature on oceans cause more evaporation that results in more precipitation. Solar radiations are either absorbed in aerosols or are reflected back that increase or decrease the temperature of planet earth. Global warming is affecting our cryosphere badly. It could result into severe levels of depletion of glaciers [3].

About 25% of world population is inhabited within mountains or in foothills of mountain [4]. Glaciers and ice caps are among the most captivating features of nature. Glaciers are formed due to accumulation of ice accompanied by flow in response to gravity and internal frictions. But they are close to the melting point and respond intensely to climate change. Glaciers are important indicators of global climate. Mountain glaciers provide ecological services and water resources on which a number of flora and fauna is dependent. Depletion in glaciers cause irreversible losses like freshwater, agriculture production and human susceptibility [5].

Due to glacier depletion, new regions are being exposed each year that were beneath the mountain glaciers. New lakes are being formed and all such areas are resulting into glacier lakes that present a hazard to all life forms living in regions close to mountains [6].

*E-mail: noorulane692@gmail.com.*

Melting of glaciers on the top of mountains cause the melted ice to flow down the hills. The water flows down carrying with it all the debris and accumulates at the bottom region in the form of glacial lakes. Continuous melting on top of the hills add much water to this lake and the water outbursts by breaking up the small walls of the lake. Consequently, floods appear and cause immense damages to human populations, production fields and infrastructure [7].

The melting glaciers are estimated by the images captured with the help of satellites. Satellites give us broader aspects of glaciers. Images can be used to assess the rate of growth or depletion of glaciers in any specified area. Glaciers are towards the rapid depletion. A prediction was made that if present warming persists then about a quarter of mountain glaciers will disappear by year 2050 and all the glacier mountains will be vanished by 2100 [8].

## 2. Worldwide status of glaciers

Status of glaciers has been reviewed according to their distribution in different continents.

### Asia

Hindukush-Karakoram-Himalaya is the largest mountain series and is considered as a blessing for South Asia as it provides water to all its major rivers. It draws border between China and other Asian countries like Pakistan, Nepal and Bhutan. This mountain range is located sidewise and hard to be distinguished as individual ranges. These are experiencing depletion in ice and snow reserves on a much rapid level [9].

Temperature is being recorded to be increasing upward as the years are passing by. In last 28 years there is upward creeping of 30°C by 725m higher altitude. Temperature is continuously being increased in areas covered under these mountain glaciers. In last decade, temperature has been increased drastically. One such event resulted into a destructive flood that caused major devastation in Pakistan during June, 2005. Siachen glacier is located in Karakoram Range in Himalaya Mountains and is experiencing major depletion. It has decreased up to 2 km in length and has lost 17% of its form from 1989-2006. There is an increase of 4°C temperature during this period [3]. Siachen glacier is a controversial landform between two atomic states i.e.

• Noor Ul Ane is currently pursuing master's degree program in Philosophy as Research Scholar in Department of Zoology, University of Gujrat, Pakistan.

India and Pakistan due to which data collection and scientific approaches couldn't be applied properly in this site.

July 1st glacier is located in Tibetan plateau of inland China. It has decreased in its mass in last 27 years (1975-1985) but more drastically in last 17 years (1985-2002). It has lost 5% of its mass. 4% of this mass is lost in last 17 years. 50% above water discharge has also occurred during these last 17 years than past years [10].

#### **North America**

Glaciers in Alaska and neighboring Canada cover about 13% of glaciers on earth [11]. These have been going through retreating of their glaciers. The average rate of thinning of these glaciers in initial years of 1900s was estimated to be -52m/year while in from mid 1900s to beginning of twenty first century the level has approached a rate of -1.7m/year based on a sub sample of 28 glaciers. Some glaciers are thinning drastically like Columbia, Tazlina and Turquoise glaciers. There are some regions in Alaska where the glaciers are expanding like Hubbard and Taku but most regions of Alaska are getting deprived of snow gradually [12].

#### **South America**

Andes Mountains of South America constitute three types of glaciers i.e. tropical glaciers, Central Andes and Patagonia ice fields. Tropical glaciers of Andes Mountains have gone through significant decrease. Between 1950s and middle of 2000s 51% of area covered by glaciers was lost in Colombia. From 2002-2007 the glacier area decreased from 60 km<sup>2</sup> to 45 km<sup>2</sup>. The remaining area of Colombian glaciers are located on volcano that may increase the pace of ice depletion [13].

Glaciers in Ecuador have also been located on volcanoes. The Antisana Glaciers have shown interesting trend of advancement and decline in past some years. Glaciers were declined from 1995-1998 then advanced from 1999-2001. There was another year of gaining mass of a few meters in 2008. Since then, this glacier is again in phase of retreat [14]. The southern part of Cordillera Blanca has decreased 60% in its area since 1955. If this continuous depletion sustained then it may disappear before 2045 [15].

#### **Europe**

European Alps are under scientific estimation and analysis for global glacier retreat. European Alps had reached their maximum extent around 1850. Since then area lost is estimated to be 35% until 1970s and 50% until 2000s [16]. Overall ice bulks in 1850, 1970s and 2000 are assessed to be about 200 km<sup>3</sup>, 100 km<sup>3</sup> and 75 km<sup>3</sup>, respectively. Advancement in glacier mass was seen in middle of twentieth century in this area but there was a retreat after 1985 onwards. As a result annually 5-10% decline is seen in 2003 [17].

Swiss Alps are also facing retreat in this phase of global glacier depletion. The area of Swiss Alps is increasing and there is more water that is produced from melting that is forming new lakes. In these areas new topography is being revealed each year gradually due to continuous melting of ice [18].

#### **Africa**

Tropical glaciers in East Africa are facing serious retreat since the end of 19th Century. One such example is Kilimanjaro glacier of east Africa. It is going through serious depletion of snow and has got major attention of media and scientific society. In 1880 its areas was estimated to be 20 km<sup>2</sup> which had declined to

only 2.6 km<sup>2</sup> in year 2000 [19].

Kibo glaciers are located in foot of Kilimanjaro. They are getting deprived of snow due to various factors like variable humidity, tourism and also being a dormant volcano. These have got attention of scientific society early and therefore research stations are being developed there to gather information about the trend and factors of its retreat [20].

Other tropical glaciers in Rwenzori Mountain range of east Africa are also showing effects of drier habitat in Africa since 1880 in the form of drop in snow mass. The retreat in this area is considered to be because of dry climate and more shortwave radiations.

#### **Antarctica**

Glaciers in Antarctica are not in serious depletion like other glaciers in different parts of world. These are reported to be either expanding or being constant. But there are some reports that conclude the recession of glaciers in this biggest continent of ice. Satellite reports about Pine Island Glacier, west Antarctica have been reviewed. According to these reports the glacier is retreating as the years are passing by due factors of global warming and warm water that is invading gradually at deep sea levels in this region [21].

#### **3. Factors involved in glacier shrinkage**

Glaciers are facing major depletion due to man induced greenhouse gases and consequently climate change. Atmosphere of planet earth is getting warmer year by year and is posing a serious threat to upcoming years of glaciers existence. If the factors remained constant then the glaciers may get disappeared from surface of earth pretty soon.

#### **Global Warming**

Increased industrialization and population has turned the environmental protection issues to be secondary. In his purpose of fulfilling the demands of population, man has been continuously ignoring the impacts of his activities of the environment. His actions are having an equal but opposite reaction. Temperature of the planet earth is increasing continuously that is predicted to have serious consequences in future.

#### **Greenhouse gases**

Man has been adding much heat into our environment resulting from advance industrialized civilization. Harmful gases resulting from these activities go into upper atmosphere and absorb solar radiations instead of reflecting them back thus resulting in rise of earth temperature. Carbon dioxide is a major greenhouse gas. Its quantity in human environment has increased drastically. Data received from various stations concerned with amount of carbon dioxide in atmosphere has revealed that in 1956 carbon dioxide was 356 ppm while now it has increased up to 385 ppm. Other greenhouse gases include methane and nitrous oxide. These two are in far less quantity than carbon dioxide but damage our environment likewise [22].

#### **Climate change**

The climate of planet earth has been changed since the termination of nineteenth century. Twentieth century has given us much warmer climate and high precipitation. As the atmosphere is getting warmer there is response of glaciers towards it in terms of their decline. Deforestation has contributed much to the warmer climate.

#### **4. Impacts of glacier shrinkage on environment**

Glacier shrinkage can have serious impacts over environment.

There are a number of inhabitants at the foothills that are at direct risk of extinction of severe damage by the continuous runoff water. Sea level may rise, animals may lose their habitats, drastic floods can occur resulting into irreversible damages.

#### **Rise in sea level**

Warmer climate and rapid melting of glaciers are adding in increasing sea level. Sea level may rise up to 0.1m at the end of this century. All this sea level rise will have major contributors from Arctic Canada, Alaska and Antarctica, this trend will rise in this century. The glaciers will lose 21% of their mass and some may have to be deprived of their 75% mass [23].

#### **Habitat Loss**

Continuous depletion of ice is a threatening sign to many species that may get extinct in near future. Animals living under icy habitat or animals that are far away from ice but they get disturbed indirectly. Examples include, polar bears that inhabit snow habitats in Canada might gone extinct if the conditions went persistent. Ice worm spends its life on ice. It feeds on algae and roams on ice during night. It may be in trouble as the conditions are developing. Its functioning is carried out at 0°C and it might be vanished with warming climate [24].

Coral reefs are affected indirectly. Glacier retreat is involved in rising sea level. Reefs need sunlight for photosynthesis, as the sea level is rising it is seemed difficult for them to cope with changing conditions [25]. Bengal Tigers have also been threatened as their habit is threatened to be disturbed with sea level rise in mangroves of Bangladesh and India.

#### **Water Shortages**

Glaciers are a source of freshwater for many communities around the world. Water being supplied by the glaciers is consumed by human beings as well as all other animals inhabiting the area. As the glaciers are melting, there is an increase in supply of water in all the water bodies. Only Himalayan glaciers provide water to a number of rivers thus fulfilling water needs of about 2 billion people. In north Tien Shan Mountains of Kazakhstan, 90% of water is used in agriculture [26]. In dry Andes glaciers contribute more than rains to rivers even during rainy season [27]. Due to depletion in glacial ice these rivers may face decrease in water supply from glaciers. Most large cities in Ecuador, Peru and Bolivia depend on meltwater from speedily fading glaciers for their water supply and hydroelectric power, and many communities are already suffering scarcities and struggles over use [28].

#### **Flooding**

Rapid melting of glaciers might lead in raising the levels of water in rivers at much dangerous intensities. In addition runoff from glaciers can form new glacier lakes. Continuous discharge of water from glaciers as a result of melting can cause destructive situations like bursting of glacier lakes [6]. Such conditions can cause catastrophic events that may cost life of people, agricultural land and infrastructure.

A drastic flood visited Pakistan in 2005 that turned over all the infrastructure, agricultural land and economy of the country. Thousands of people got homeless while a number of them lost their lives. Agricultural lands became barren and cattle were swept away in the flood water [7].

In 1985, such a flood in Nepal killed numerous people and ruined bridges, houses, land, and a nearly finished hydropower plant [29]. A recent study found that 44 glacial lakes in Nepal

and Bhutan are in instant risk of spilling over as a result of climate change.

In Peru, a piece of glacier ice fell into Lake Palcacocha in 1941, producing a flood that killed 7000 people, recent satellite photos disclose that another mass of free ice is poised over this lake, frightening the lives of 100,000 people below [30].

#### **Threats to inhabitants**

Due to increased melting of glaciers, its inhabitants can suffer a lot in terms of frequent landslides and soil erosion. Soil erosion can damage agricultural lands seriously. Water shortage leads to weakening of agricultural soil quality. Soil erosion might add to the damage that is already present.

#### **CONCLUSION**

Glaciers are one of the most important and irreversible natural resources of earth. Glaciers are facing a drastic shrinkage due to rising temperature of earth globally. Glaciers are vanishing gradually from all continents of earth. Global warming has become a root of all the damaging situations that are being arisen on planet earth day by day. Glacier shrinkage has adverse impacts leading us to rising sea level, floods, water shortages and other major threats. Glaciers are a basic source of freshwater and also a home to many endangered species. Its disappearance will cause such severe conditions whose solutions would slip away from scientific approaches.

#### **RECOMMENDATIONS**

Glaciers are being disturbed by human beings. Natural resources of earth are continuously being polluted by its own inhabitants. Regular monitoring of glaciers and glacier lakes is needed. Proper research stations should be installed near glaciers to record recent data of glaciers. Anthropogenic activities should be controlled near glaciers. Latest data should be collected to estimate the fresh status of glaciers and policies should be made accordingly as soon as possible.

#### **REFERENCES**

- [1] K.E TRENBERTH, P.D JONES, P AMBENJE, R BOJARIU, D EASTERLING, A KLEIN TANK, D PARKER, F RAHIMZADEH, J.A RENWICK, M RUSTICUCCI, B SODEN, P ZHAI. 'Observations: surface and atmospheric climate change'. In: Solomon S, Qin D, Manning M et al (eds) Climate change: the physical science basis. Contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge. (2007)
- [2] RS BRADLEY, FT KEIMIG, HF DIAZ, DR HARDY. 'Recent changes in freezing level heights in the Tropics with implications for the deglaciation of high mountain regions'. *Geophysics Res Lett.*36:L17701. (2009)
- [3] G RASUL, Q. DAHE, Q. Z. CHAUDHRY. 'Global Warming Rand Melting Glaciers along Southern Slopes of Hkh Ranges'. *Pak. J. Met.*5:63-76. (2008)
- [4] M MEYBECK, P GREEN, C VOROSMARTY. 'A New Typology for Mountains and other Relief Classes: An Application to Global Continental Water Resources and Population Distribution', *Mount. Res. Dev.* 21, 34-45. (2001)
- [5] J XU, R GRUMBINE, A SHRESTHA, M ERIKSSON, X YANG, Y WANG, A WILKES, 2009. 'The melting Himalayas: cascading effects of climate change on water, biodiversity, and livelihoods'. *ConservBiol.* 23:520-530. (2009)
- [6] C HUGGEL, W HAEBERLI, A KAAB, D BIERI, S RICHARDSON. 'An assessment procedure for glacial hazards in the

- Swiss Alps'. *Canadian Geotechnical Journal*. 41(6): 1068-1083. (2004)
- [7] G RASUL, Q.Z., CHAUDARY, A MAHMOOD., KW HYDER, Q DAHE. 'Glaciers and glacial lakes under changing climate in Pakistan'. *Pak. J. Met.* 8: 1-8. (2012)
- [8] J OERLEMANS. Quantifying global warming from the retreat of glaciers. *SCIENCE*. 264: 243 - 245. (1994).
- [9] G RASUL, Q. Z. CHAUDHRY. Global Warming and Expected Snowline Shift along Northern Mountains of Pakistan. Proc. Of 1st Asiatic Sympos. Yokohama, Japan. (2006)
- [10] A SAKAI, K FUJITA, K DUAN, J PU, M NAKAWO, T YAO, ' Five decades of shrinkage of July 1st glacier, Qilian Shan, China'. *Journal of Glaciology*. 52: 11-16. (2006)
- [11] W. HAEBERLI, H. BOSCH, K. SCHERLER, G. OSTREM, C. WALLE'N. 'World Glacier Inventory'. International Association of Hydrological Sciences (IAHS), United Nations Environment Programme (UNEP), and United Nations Educational, Scientific, and Cultural Organization (UNESCO). (1989)
- [12] AA ARENDT, KA ECHELMAYER, WD HARRISON, CS LINGLE, VB VALENTINE, Rapid Wastage of Alaska Glaciers and Their Contribution to Rising Sea Level. *SCIENCE*. 297: 382-385. (2002)
- [13] G POVEDA, K PINEDA. 'Reassessment of Colombia's tropical glaciers retreat rates: are they bound to disappear during the 2010-2020 decade?' *Advances in Geosciences* 22:107 - 116. (2009)
- [14] M VUILLE, B FRANCOU, P WAGNON, J IRMGARD, G KASER, B MARK, R BRADLEY, 2008. 'Climate change and tropical Andean glaciers: Past, present and future'. *Earth Science Reviews*. 89: 79-96. (2008).
- [15] P PEDUZZI, C HEROLD, W SILVERIO. 'Assessing high altitude glacier thickness, volume and area changes using field, GIS and remote sensing techniques: the case of Nevado Coropuna (Peru)'. *The Cryosphere*. 4: 313 - 323. (2010)
- [16] M ZEMP, W HAEBERLI, M HOELZLE F PAUL. 'Alpine glaciers to disappear within decades?' *Geophysical Research Letters*, 33(L13504). (2006)
- [17] M ZEMP, R FRAUENFELDER, W HAEBERLI, M HOELZLE. 'Worldwide glacier mass balance measurements: General trends and first results of the extraordinary year 2003 in Central Europe'. *Data of Glaciological Studies*. 99: 3-12. (2005)
- [18] S TERRIER, F JORDAN, AJ SCHLEISS, W HAEBERLI, C HUGGEL, M KUNZLER. 'Optimized and adapted hydropower management considering glacier shrinkage scenarios in the Swiss Alps'. *Dams and Reservoirs under Changing Challenges - Schleiss & Boes (Eds)*. Taylor & Francis Group, London. (2011)
- [19] LG THOMPSON. 'Kilimanjaro ice core records: evidence of holocene climate change in tropical Africa'. *SCIENCE* 298: 589-593. (2002)
- [20] S HASTENRATH. 'Variations of East African climate during the past two centuries'. *Climatic Change*. 50 (1-2): 209-217. (2001)
- [21] EJ RIGNOT. 'Fast Recession of a West Antarctic Glacier'. *SCIENCE*. 281: 549-550. (1998)
- [22] ML KHANDEKAR. 'Global Warming, Glacier Melt & Sea Level Rise: New Perspectives.' *Global Warming*, Stuart Arthur Harris (Ed.). INTECH. (2010)
- [23] V RADIC, R HOCK. 'Regionally differentiated contribution of mountain glaciers and ice caps to future sea-level rise'. *NATURE GEOSCIENCE*. Macmillan Publishers. (2011)
- [24] DH SHAIN, TA MASON, AH FARREL, LA MICHALEWICZ. 'Distribution and behavior of ice worms (*Mesenchytraeus solifugus*) in south-central Alaska'. *Canadian Journal of Zoology*. 79:1813-1821. (2001)
- [25] HOEGH-GULDBERG, OVE. "Climate Change, coral bleaching and the future of the world's coral reefs." *Marine Freshwater Research*. 50:839-866. (1999)
- [26] H SCHRODER, S HARRISON, DG PASSMORE, I SEVERSKIY, V VESELOV, G GLAZARIN. 'Assessment of renewable ground and surface water resources and the impact of economic activity on runoff in the basin of the Ili River, Republic of Kazakhstan'. *Kazakh Academy of Sciences, Almaty, Kazakhstan*. 314. (2002)
- [27] P WAGNON, P RIBSTEIN, G KASER, P BERTON. 'Energy balance and runoff seasonality of a Bolivian Glacier'. *Global and Planetary Change* 22(1-4):49-58. (1999)
- [28] H LINIGER, R WEINGARTNER, M GROSJEAN. 'Mountains of the World: Water Towers for the 21st Century'. *Mountain Agenda*, Berne, Switzerland. (1998)
- [29] M VUICHARD, M ZIMMERMANN. 'The 1985 catastrophic drainage of a moraine-dammed lake, Khumbu Himal, Nepal: cause and consequences'. *Mountain Research and Development* 7(2):91-110. (1987)
- [30] DE STEITZ, A BUIS. 'Peru in peril? NASA takes a look at a menacing glacier'. (2003).