Research Article

Threats of Global Warming for Pakistan's Agriculture: An Evidence from Shigari Kalan Watershed, Skardu

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Abstract | Many researchers argued that increasing global temperature will result in waning glacier based freshwater availability in future. River Indus fed by glaciers is critical for Pakistan as it is irrigating its 80% of agricultural land. Shigari Kalan watershed is one of the water sheds located in Skardu, Northern Pakistan, which also contributes to River Indus flowing to Pakistan. The aim of instant research is to evaluate the correlation amid temperature and the rate of glacier/snow melt which could have future implications for water availability in the River Indus flowing into Pakistan for which data pertaining to snow/glacier melt from the Shigari Kalan watershed was regularly monitored during the period spread over September 2015 to November 2015 and March 2016 to September 2016. Results showed that in the flow discharges of the stream during summer months was much higher with peak in June. The snow/glacier melt increases with air temperature from 12.5 C onwards and at 20C onwards it gets exponential rate. From the results it transpires that the effect of global warming in Himalaya and Karakorum Mountains has already set in. Any further increase in global temperature as predicted in many studies will further increase glacier melt rate which could result in extinction of glaciers in the long run. Such a situation will have serious implications for Skardu and water availability in River Indus and thus for Pakistan whose major water requirements are met from snow/glacier melt from the River Indus.

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Introduction

Researchers in a number of studies assessed that observed as well as projected data on climate reveals warming trends at global level. Such trends signify substantial increase in temperature. The increase in temperature to result in heavy precipitations, heat or cold waves, frequent extreme weather events such as floods and droughts and increased glacier melt Salik et al. (2015).

Sharma and Sharma (2008) argued that more than one billion masses in Asia are to be affected due to waning freshwater availability by 2050. Himalayas' Glacier melt is anticipated to upsurge flooding and avalanches affecting water resources during 2 o 3 decades. As a result of receding glaciers, river flows in the long run would decrease putting the population at great risk for survival. Climate changed based water scarcity by 2015 has also been argued by WWF (2007).

Pakistan's dependence for water is largely glaciers based. River Indus fed by glaciers extends to parts of countries including Pakistan, Afghanistan, China and India (WRI, 2003). River Indus is critical for a population of more than 200 million dwelling in Pakistan and irrigating its 80% of agricultural land (Rizvi, 2001). The River Indus's watershed is rich in biodiversity, important region for water birds and useful for freshwater fauna.

Shigari Kalan watershed is one of the 11 water sheds located in Skardu, Northern Pakistan, which also contributes to River Indus flowing to Pakistan. Out of eleven watersheds, 4 watersheds are located upstream of Right Bank Canal namely Darzes, Hussain Abad, Thorgo Payeen and Thorgo Bala. Rest of the 7 watersheds are situated upstream of Left Bank Canal of Satpara Dam and these are Burgay, Gayul, Shigari Bala, Shigari Kalan (Thayur), Tangos, Ghor Ghun (Chunda) and Khosho spring. The total catchment of these watersheds is 90067 acres. Along the Left Bank Canal (LBC), Shigari Kalan is the 4th watershed, which has an area of 2,530 acres with existing cultivable command area of 664 acres. A natural stream come out of Shigari Kalan's watershed and crosses the LBC of Satpara Dam.

The research studies conducted by a variety of researcher across the globe reveal that increase in global temperature due to global warming is causing increased snow/glacier melt in various parts of the world which is an expected threat of drying up of glaciers/snow melt based river systems. A few studies are presented to support the significance of instant study. Zafar Pervaiz Sabri (2014) stated that the Himalaya-Hindu Kush range is the source of water for rivers and 15000 ice peaks and 5000 glaciers in Pakistan were melting fast signifying that rivers in Pakistan would dry up in the next 80 years. According to Qin Dahe (1999) there are 18,065 glaciers in whole of the Himalayan Range, with a total area of 34,659.62 km^2 and increasing global temperature is a threat to these glaciers due to increasing melting rate. Ageta et al. (1999) stated that bulk of Himalayan glaciers were decreasing and waning over the past 30 years. Arendt et al. (2002) while discussing North America argued about melting of glaciers while Rignot et al. (2002) in a research on Antarctica argued that due to increase in temperature the underneath glacier is melting and land and sea is spreading in Antarctica. Haeberli et al. (1998) claimed that if current trends of global warming continue, the European Alps will lose major parts of their glacier coverage within the next few decades. Thompson et al. (2002) showed that since early 1990, 60-70 percent area of tropical glacier has decreased in Africa.

The aim of instant research is to evaluate the correlation amid temperature and the rate of glacier/snow melt which could have future implications for water availability in the River Indus flowing into Pakistan.

Materials and Methods

Study area

The data for this research article was collected during a study conducted by the authors for Aga Khan Foundation Pakistan sponsored by USAID in 2015-16 to assess the water sources other than Satpara Nullah in the command area of watersheds up-streams of Left Bank Canal and Right Bank Canal constructed as part of Satpara Dam project. The Shigari Kalan watershed is situated at Left Bank Canal of the Satpara reservoir.

Collection of information/data

For the collection of data pertaining to snow/glacier melt from the Shigari Kalan watershed, a flow measuring weir was constructed at the measurement point is located at latitude 35.28351 N, longitude 75.52886 E and altitude of 2543 m. The dimensions of the weir consist of 21ft width, 3ft side wall height above the ground, 10 ft upstream wing walls with 1.5ft wall thickness. The flow discharge out of the watershed was regularly monitored during the period spread over September 2015 to November 2015 and March 2016 to September 2016. It is important to mention here that flow was measured in all months except December to February. However, for these months the flow data was assessed based on November and March data assuming that variation in spring discharge is relatively low. The measurement results were validated though focused group discussions and key informant interviews with the elderly dwellers of the command area of Shigari Kalan watershed.

The data pertaining to temperature and precipitation was collected through secondary sources particularly Pakistan Meteorological Department.

Data analysis

Both the primary information collected from survey and secondary information collected from various means were coded, tabulated and analyzed by using Microsoft Excel.

Results and Discussion

In the surroundings of Satpara Dam Reservoir at Skardu, Shigari Kalan watershed is one of the eleven watersheds in existence. The watershed has surface and perennial spring water sources. The communities living in the command of Shigari Kalan watershed have been using water for their domestic needs and irrigation requirement. The relationship between mean monthly flow and air temperature was developed as shown in Figure 1 which reveals that the flow discharges of the stream during winter months (November, December, January, February, March and April) were relatively low and ranged from 3.62 to 4.62 cubic feet per second (cfs) with overall average of 3.95 cfs. This water flow is mostly from spring water; the contribution of glacier melt was of hardly any quantity. In summer months, May to September, water flow is much higher with peak in June. The summer water flow is mainly generated from snow/glacier melt. The snow/glacier melt increases with increase in air temperature and maximum flow discharge was observed during the month of June and then decreases with decrease in air temperature. During the summer months the flow discharge ranged from 10.82 to 67.47 cubic feet per second (cfs) with overall average of 28.63 cfs. The snow/glacier melt was the major contributor i.e. 86% and spring contribution was about 14%. However, in winter months only spring water is available for drinking and other domestic usage for the people living in the command of Shigari Kalan watershed.

The relationship between mean monthly flow and air temperature was developed as shown in Figure 2.

It can be seen from the Figure 2 that the snow/glacier melt increases with air temperature from 12.5 C onwards and after 20C it gets exponential rate. Maximum flow discharge at 67.47 csf was recorded during the month of June and then decreases with decrease in temperature. With increase in temperature of 2-5 degree may significantly increase the flow discharge during the month of June and July that could result in glaciers retreat in future as also argued by Qin Dahe (1999), Ageta et al. (1999), Haeberli et al. (1998) and Thompson et al. (2002).

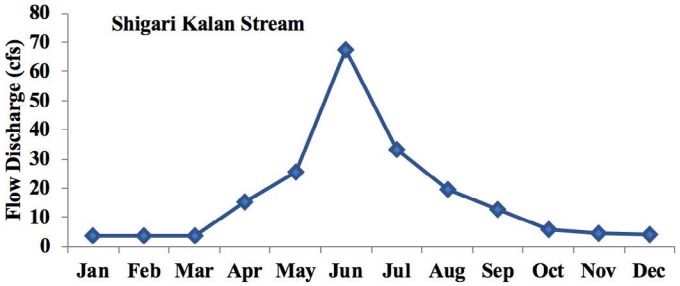

Figure 1: *Average monthly flow discharge out of Shigari Kalan watershed.*
Source: *Field data.*

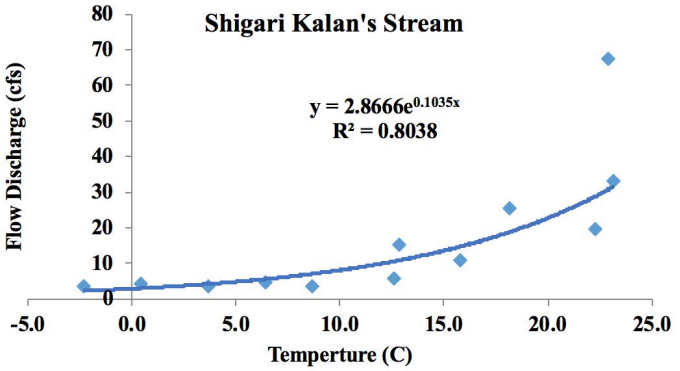

Figure 2: *Relationship of flow discharge vs air temperature.*
Source: *Field data*

During Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs), it was revealed that during the months of March, crops sowing season, irrigation water quantity is much less as only perennial spring is the main source during these months that could not fulfill irrigation demand. Thus, irrigation water availability is not sufficient to sow all cultivated land. Farmers' argument was verified through crop water requirement analysis. Shigari Kalan has an irrigated command area of 664 acres. Wheat is the main crop grown on 60% cropped area in rabi seasin. Barley is another important crop occupies 17% area followed by potato (7%), vegetables (6%) while each of the orchards and other crops occupy 4% area. The crop water requirement analysis shows that the irrigation water demand during the crop season ranged from 0.34 to 10.79 cfs with overall average of 5.42 cfs. The analysis revealed that it is month of March which is also crop sowing season when irrigation water availability is less than demand. In the month of March, after meeting domestic requirement only 0.82 cfs is available against a demand of 3.55 cfs. Thus, irrigation water shortfall in the month of March comes to 2.73 cfs. The KIs narrating their old days experience stated that water availability even in summer moths was not in abundance 20 years ago and farmers were strictly observing water turn day and nights. However, from

last 15 years or so we are receiving water in excess of requirement in summer and water is even allowed to non water right holders and substantial quantity of water flows to River Indus. These results show that with increase in global temperature, melting rate of snow/glaciers has increased over the last 15 years which means increased melting may result in shrinking of glaciers and snow bound areas in the long term. These finding are supported by Qin Dahe (1999), Ageta et al. (1999), Rignot et al. (2002), Arendt et al. (2002) and Haeberli et al. (1998).

Conclusions and Recommendations

From the results and discussions it transpires that global warming in Himalaya and Karakorum Mountains has already increased the rate of snow/glacier melt. Any further increase in global temperature as predicted in many studies will further increase glacier melt rate which could result in extinction of glaciers in the long run. Such a situation will have serious implications for Skardu and water availability in River Indus viz a viz Pakistan whose major water requirements are met from snow/glacier melt from the River Indus.

As a policy prescription, following recommendations are made;

- Projects may be launched aiming at
  1). Greenhouse gases control
  2). Carbon sink.
  3). Water reservoirs and water harvesting.
- Awareness raising of general public about conservation of water to address future water crises.
- Further research may be conducted in other parts of the world to authenticate the result.

Author's Contribution

Irshad Khan Abbasi and Melad Karim: Contributed to conception of idea and provided guidance during the period of study.
Muhammad Zulfiqar, Muhammad Jamal Khan and Muhammad Tariq: Helped in designing the study and subsequent visit and data collection mechanism as well as data analysis.
Jawad Ali and Rizwan Ahmad: Contributed in checking the analysis and drafting research article.

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