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The Impact of Glacier Melts on Food Production in North Zone of Russia

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Abstract

Food production has emerged as a critical issue for nations with varying levels of economic development, which is always had to contend with an unfavorable weather.The climatic variability changes including temperature, rainy days, humidity, precipitation and sunny days. Therefore, this have direct and indirect effects on food production (agriculture, aquculture, meat and dairy products). One of the regions where unfavorable climate is causing significant mass loss of glaciers melt in Siberia (the northern part of Russia). As well as, climate change and glaciers melting is projected to positively and negatively effects the availability of foods and food productions in this region. In this research, we tried to draw attention to the effects of ice melt occurring due to global warming in the northern region of Russia on food production. For this purpose, some climate parameters (Temperature, Total Precipitation, Rainy days, Humidity, 1991-2021; Sunshine duration, 1999-2019) observed for many years in the northern regions of Russia were statistically analyzed. As a result of the study, the average Temperature: 5.7 ^{0}C ± 10.268; Min temperature: 1.9 ^{0}C ± 9.412; Maximum temperature: 9.0 ^{0}C ± 11.00; Total Precipitation: 678 mm year^{-1} ± 14.607; Humidity: 76% ± 8.039; Number of rainy days: 89 days year^{-1} ± 0.831; Sunshine duration: 6.3 hours day^{-1} ± 4.345. In other studies conducted on climate change and food production in this region, it can be said that food production is affected by global warming and this situation shows an increasing trend.

Keywords: Global Warming, Glacier Melts, Food Production, Russia

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INTRODUCTION

Glaciers are large masses of ice that develop from compacted snow over a long period of time in areas when snowfall is greater than melting. They can be found in arctic locations as well as high-altitude mountainous locales. Glaciers are regarded as one of nature's best "thermometers" since they act as recorders and sensitive indicators of climate change (Pollack, 2010), as well as they integrate and react to most key climatic prameters such as precipitation, temperature, humidity, cloudiness and radiation (Thompson et al., 2004). The cumulative volume loss of ice sheets, sea ice, and glaciers is a result of global warming's considerable impact on the cryosphere in contemporary Earth surface ecosystems (Howat and Eddy, 2011; Kochtitzky et al., 2022; Lindsay et al., 2015; Shepherd et al., 2018; Zemp et al., 2019). The North Zone of Russia, It is affected by glacier melt because of its cooler climate and abundance of glaciers, and includes areas like Siberia and the Russian Arctic (Fondahl et al., 2020; Vorobyeva et al., 2015). The middle of the 19th century, and climate change has increased more over the recent decades in all Polar Regions than in any other region of the planet (Assessment, 2004).

Enough water is provided by snow and glacier melt to support the agriculture and cultivation of food crops necessary for millions of people to maintain a healthy diet (Biemans.,et al 2019). In many areas, glacier meltwater provides a significant source of freshwater for irrigation (Sorg et al., 2012).

As glaciers shrink and melt, less meltwater is available, which causes water shortages during crucial times for agriculture. Crop yields and agricultural output may suffer as a result (Munir et al., 2021; Biemans et al., 2019). In dry seasons, abrupt influxes of water can occur as a result of glaciers melting more quickly, disrupting ecosystems and reducing the amount of water available for agriculture downstream (Vuille et al,.2018). (Gaudard et al., 2018; Vuille et al., 2018; Ingram et al., 2011).

Thus, climate change has had a strong influence on the Arctic ecosystems and to mitigate the impacts of glacier melts on food production in the North Zone of Russia, it is important to focus on sustainable water management practices, including the efficient use of available water resources and the development of alternative irrigation techniques. Furthermore, promoting diversified agricultural practices, such as agroforestry and greenhouse farming, can help reduce dependence on glacier meltwater and enhance food production resilience in the face of changing climatic conditions (Unlukal and Erguven, 2024).The objective of this study is to examine the Impact of glacier melts on Food Production in North Zone of Russia. However with current and projected environmental changes on the horizon there is an urgent need to measure and analysis the impact of these changes.

MATERIALS AND METHODS

This study was conducted to assess climate change in the northern regions of Russia. The location of the study area is shown in Figure 1. The northern section of Russia lies into the Arctic Circle It spans the regions of Arkhangelsk Oblast. It is renowned for its folk art traditions, particularly for its wooden construction, carvings of wood and animal bones, and painting (Lebedev, 2022; Nakvasina et al., 2017; O'Shea and Zvelebil, 1984; Duryagin and Knyazev, 2022; Lakhtine, 1930).

Figure 1. The location of study area

Mountain glaciers are common in the continental portion of the nation, while continental ice sheets are found on the islands and archipelagoes of the Russian Arctic region, where they currently span an area of around 3,480,000 km^2. In the Russian Arctic, continental ice sheets are found on islands and archipelagoes, while mountain glaciers are common in the continent where the ice currently covers an area of about 3,480.000 km^2 (Khromova et al., 2016).

However the entire amount of Arctic sea ice has drastically decreased in recent decades due to the region's swift climatic change (Mokhov, 2019; Alekseev, 2015; Alekseev et al., 2016; Mokhov, 2015). As result many Russian glaciers have already shrunk to their lowest points. İn this study linear regression method and the standard deviation (SD) was calculated for the analysis of climate data.

In this study, temperature, precipitation, rainy days, humidity between the years 1991-2021 was used. Sunny hours data were used as the average of 21 years of climate data between 1999-2019. Linear regression model was used to evaluate the data. Regression analysis is a method for describing quantitative connections between one or more explanatory factors and a response variable (Rezaeianzadeh et al., 2014; Salihi and Üçler, 2021).

RESEARCH FINDINGS

In this research, some climate data were examined in the northern regions of Russia. Figure 2 shows the distribution of long-term average minimum temperature changes by month.

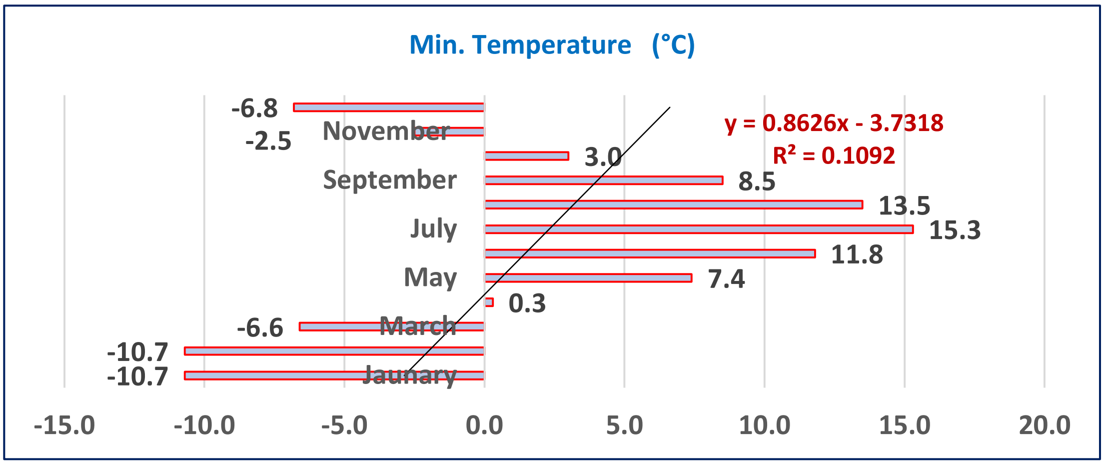

Figure 2. The Changes of Minimum temperature

The lowest minimum temperature in the northern regions of Russia was found to be in February with -1.7 °C. The highest minimum temperature was calculated as 15.3 °C in July. The long-term minimum temperature average in this region was found to be 1.9 °C. There was no significant relationship between the minimum temperatures and the R^2 value was found to be 0.1092. Figure 3 shows the distribution of maximum temperatures by month.

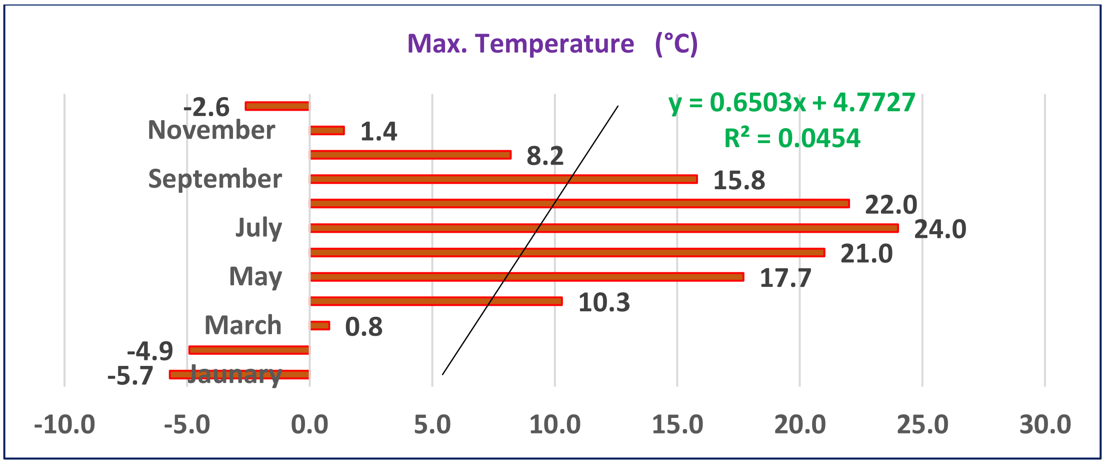

Figure 3. The Changes of Maximum temperature

When the distribution of maximum temperatures by month is examined, the highest maximum temperature was recorded as 24.0 ^{o}C in July. The lowest maximum temperature was determined as -5.7 ^{o}C in January. The average maximum temperature value for many years was calculated as 9.0 ^{o}C. It was concluded that there was no significant relationship between the maximum temperatures (R^2: 0.0454). The distribution of average temperatures by month is shown in Figure 4.

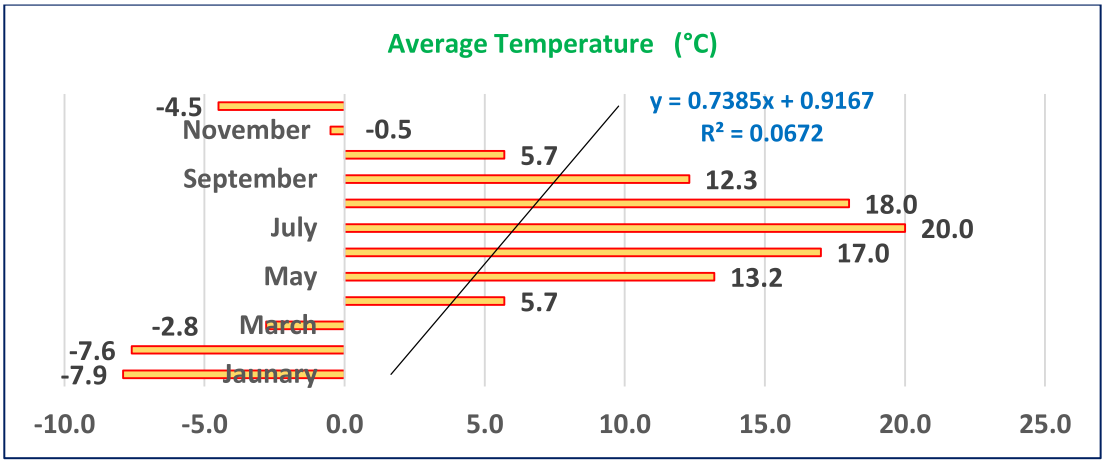

Figure 4. The Changes of Average Temperature

The distribution of average temperature values by month is examined, the lowest average temperature value was observed in January with -7.9 ^{o}C. The highest average temperature value was observed in July with 20.0 ^{o}C. The average temperature value for many years was calculated as 5.7 ^{o}C. No significant relationship was found between the average temperature values (R^2: 0.0672). The distribution of total precipitation values by month is seen in the graph given in Figure 5.

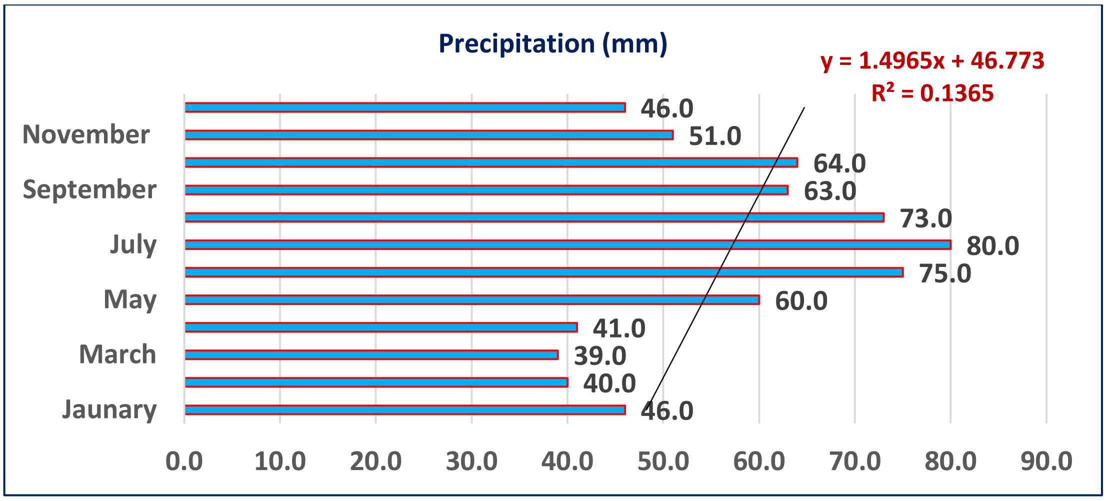

Figure 5. The Changes of Total Precipitation

The total rainfall amount calculated as the long-term average in the northern regions of Russia was found to be 678 mm. The minimum rainfall amount was 39 mm in March, and the maximum total rainfall amount was 80 mm in July. It was also seen as a result of the calculations that there was no significant relationship between the rainfall data (R^2: 0.1365). The graph regarding the distribution of the number of rainy days by month is presented in Figure 6.

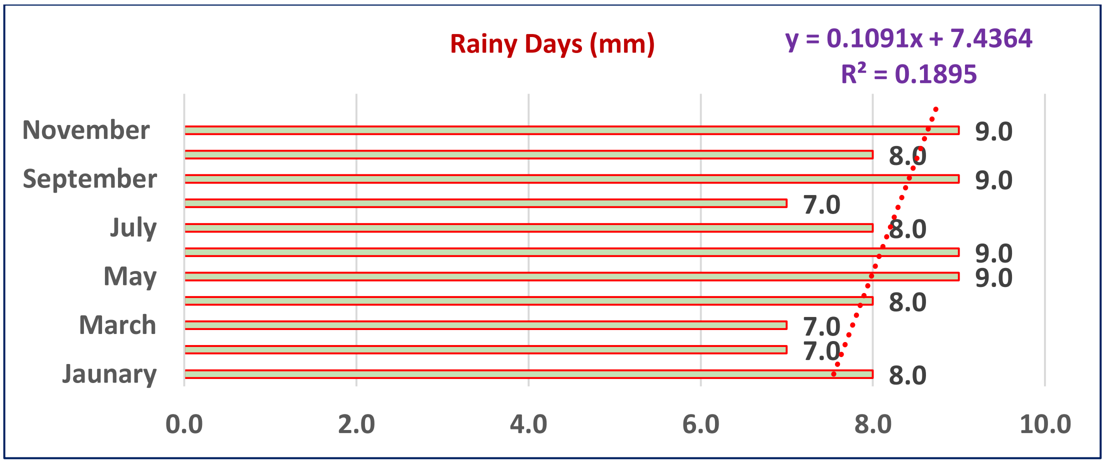

Figure 6. The Changes of Rainy days

The distribution of rainy days by month is examined, it is seen that the lowest number of rainy days is in February, March and August with 7 days. The highest number of rainy days is in May, June, September and November with 9 days. The total number of rainy days calculated by taking the long-term average is found to be 89 days. No significant relationship (R^2: 0.1895) was observed between rainy days. The monthly distribution graph of humidity amount is presented in Figure 7.

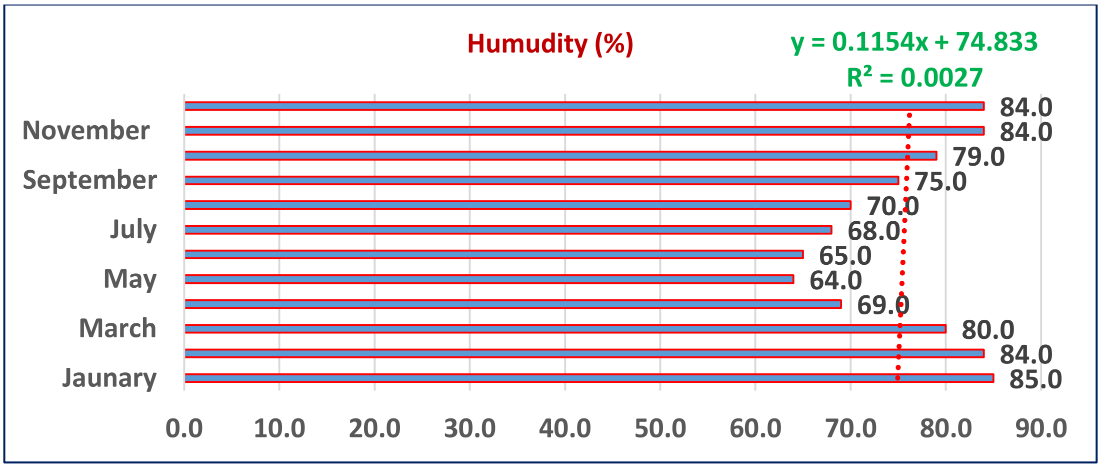

Figure 7. The Changes of Humudity changes

When the distribution of monthly humidity changes is examined, it is seen that the highest humidity rate is in January with 85%. The lowest humidity rate is observed in May with 64%. The average monthly humidity rate for many years is calculated as 76%. As a result of the analysis, it is concluded that there is no significant relationship (R^2: 0.0027) between monthly humidity rates. The monthly distribution graph of the number of sunny days is given in Figure 8.

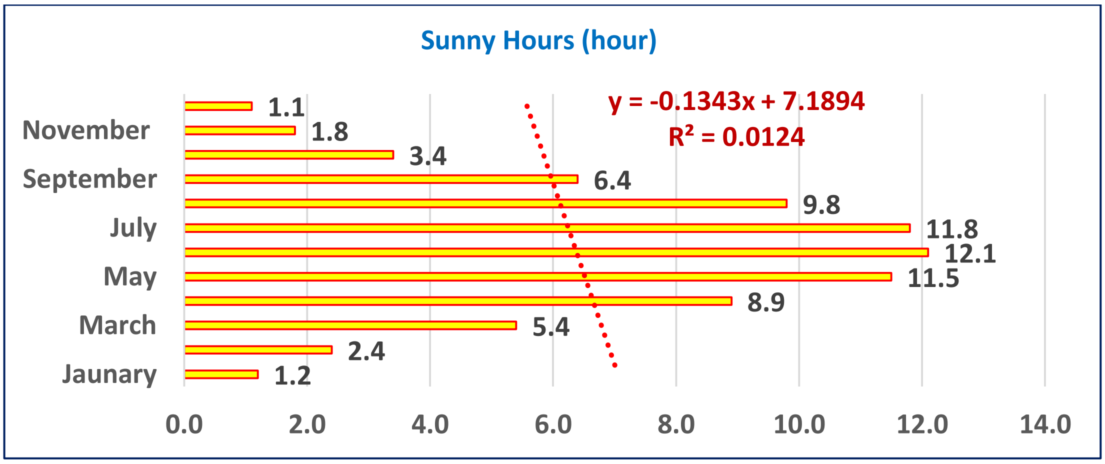

Figure 8. The Changes of Sunny days

When the distribution of sunshine durations by month is examined, it is seen that the highest sunshine duration is in June with 12.1 hours, and the lowest sunshine duration is in December with 1.1 hours. The average sunshine duration for many years is found to be 6.3 hours. No significant relationship (R^2: 0.0124) was found between the monthly distributions of sunshine durations. Long-term average values of some climate parameters in the northern parts of the Russian region are given in Table 1.

Table 1. The average or total values and standard deviation of some climate data

Climate Parameters	Average	Standard deviation
Average Temperature (°C)	5.7	10.268
Min. Temperature (°C)	1.9	9.412
Max. Temperature (°C)	9.0	11.000
Precipitation (mm) (Total)	678	14.607
Humidity (%)	76	8.039
Rainy Days (Total)	89	0.831
Sunny Hours (hour)	6.3	4.345
Temperature, precipitation, Rainy days, humudity (1991-2021) ; Sunny hours (1999-2019)		

In these analyses It is found that the total precipitation: 6798 mm ± 14.607 which is followed by maximum temperatures 9.0 °C ± 11.000, average temperature 5.7 °C ± 10.268, minimum temperature 1.9 °C ± 9.412, humidity, 76 % ± 8.039, sunny hours 6.3 hour ± 4.345 and rainy days 89 day ± 0.831.

Glacier melts are expected to have both positive and negative impacts on food production change in the Russian Arctic during the last half of the twentieth century White et al., 2007. As mentioned above, One of the regions where these changes cause the glaciers melt is Siberia (the northern part of Russia). According to researchers ,the climatic variability change is causing significant mass loss of glaciers in high mountains worldwide Kaltenborn et al 2010 . This cause direct and indirect effects on food web and food production. The average world temperature is predicted to increase 1 to 5 ^{0}C by the end of the 21 century (IPCC, 2013) So, This increase in temperature has already affected food production, traditional lifestyle, well-being and health of the Indigenous Peoples in the North Zone of Russia (Jaakkola et al., 2018). Because, the sunlight that strikes the water as the glaciers melt provides energy for microscopic algae to flourish. Wharton et al 1985. This algae feeds as a food product the minuscule zooplankton, which in turn feed birds, whales and fish. This small arctic cod or polar cod found in the North Russian that is a very important part of the food (Nilsen et al., 2022; Datsky et al., 2022).

Because, for whales, bears, seals, and birds, it serves as their primary food source. The other positive effects of lengthy snowless season and the warm temperatures during the growing season in the northern portion of Russia as a result of climate change are beneficial for plant productivity and the expansion of the feed base for reindeer's and new-born calves (Tveraa et al., 2013; Mårell et al., 2006; Bogdanova et al., 2021).

Through this food production, the people of northern Russia can survive, additionally, the melting of glaciers has an impact on the ecology, and the health of thelocal people and their traditional way of life. According another researches, warming and ice melting can result in the potential re-emergence of anthrax (Revich, 2011), biological pollution (Stibal et al., 2012). It increases the risk of forest and tundra fires (Malevsky-Malevich et al., 2008), migration of birds (Černý et al., 2021) and livetock mortality (Johnston, 2006). So, these factors and events have nagavie effects on food products and their way of lifestyle.

CONCLUSION AND RECOMMENDATIONS

According researches and studies, the North Zone of Russia, is affected by glacier melt because of its cooler climate and abundance of glaciers. Additionally, it is anticipated that the melting of the glaciers will have both beneficial and negative consequences on the region's food production and availability. From a positive perspective, plant productivity of the reindeer's feed base and newborn calves is benefited, as well as sunlight that touches the ocean as glaciers or ice melt providing energy for microscopic algae that in turn feed birds, whales, and fish. The melting of glaciers more quickly during dry seasons, unexpected water influxes can happen, which upsetting ecosystems and lowering the amount of water access for future survival. It also increases the risk of forest and tundra fires, migration of birds and livetock mortality.

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