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# Climate Change Impacts and Surface Water Accessibility Analysis in the Ghorband Sub River Basin, Afghanistan

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## Abstract

*In this study, impacts of climate change on surface water of the Ghorband Sub-River basin are assessed Ghorband River is located in the Ghorband watershed, which is a part of Afghanistan's Kabul River basin. Numerous communities live within the Ghorband Sub-River Basin, and its surface water assets have been the establishment of their jobs for numerous eras. Climate change impacts, water challenges, hydrological assessment purposes, and long-term hydro meteorological information were analyzed. The cruel yearly temperature has steadily expanded and conversely precipitation and River flow release have slowly diminished. The natural corruption and resultant climatic and characteristic calamities have profoundly influenced the vocation and prosperity of the communities inside this River basin with respect to water, horticulture, and biological system life. In conclusion, the trends show that the hydrology of the basin changed significantly over the last decades. There is not considerable instability due to the data scarcity and gaps in the data, but all results indicate a strong tendency towards different conditions.*

**Keywords:** Water accessibility, Climate change impacts, Trend analysis, River discharge, Ghorband

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## 1. Introduction

Surface water is one of the most important resources of fresh water in every region, and it is very important to investigate the effect of climate change on it. This study aimed to quantify possible climate change impacts on surface water resources in the Ghorband sub-River basin. However, over the last three decades of war and a series of droughts have caused many problems [2]. This research has assessed the hydrological regime of the Ghorband River as well as the quantity of Ghorband River water based on physical parameters, based on which was understood by us. The changes in the River flow of the Ghorband River and also compare the physical parameters of the Ghorband River with international standards, two issues that are closely linked to the impacts of climate change on surface water [2]. The quantity of the Ghorband River is important for the agriculture of Parwan province, the livelihoods of Parwan and Kabul residents, as well as the River flow of the Kabul River basin. After the information gathering on the theoretical basis of the subject and the research, the required data on the water discharge of the Ghorband River sub-basin was acquired [2]. The impacts of climate change on surface water are based on the premise that each landowner has equal rights to the surface water resource below his or her property. There will be cases where one person or entity owns multiple parcels and requests that the total water allotment below all of his or her parcels be considered in the Phase I climate change impacts on surface water [3]. Determining the total threshold based on multiple parcels is acceptable; however, to protect future property owners, certain safeguards must be in place to ensure that the water allotment and transfer between parcels are clearly documented and recorded, especially in cases where the water from more than one parcel will ultimately serve a single parcel [3]. After the analysis, it is inferred that the hydrological regime of the Ghorband River is at an alarming level because there is a huge decline in the annual water discharge, surface run-off, and precipitation [4]. The decline in water discharge due to climate change and the increasing population of Ghorband is an issue of great concern because it will affect every aspect of Ghorband citizens' lives in this research the main objective is the investigation of climate change impacts on the temporal and spatial distribution of precipitation, temperature, and surface runoff in the ghorband Sub-River basin [5].

## 2. Study Area

### 2. 1. Ghorband Sub-River Basin

The Ghorband River may be a River in Afghanistan, flowing through the Parwan Territory. It could be a tributary of the Panjshir River, at that point, a sub-tributary of the Indus River, at that point, the Kabul River. Appropriately, Ghorband River joins Panjshir River in the Bagrami locale. The Ghorband runs completely in Parwan province, where it gave its title to the Ghorband Locale. It is born within the eastern Shibar Pass (which interfaces the territories of Parwan and

Bamyan, or watersheds of the Ghorband and Kunduz Rivers) and passes on an eastward course, which it keeps up all the way through most of its course[6]. It runs along the south and the forced central extent of the Hindu Kush, accepting meltwater within the Shibar Pass area of Salang [7]. It Rivers from this in a long valley between the tall peaks of the Hindu Kush (north) and Koh-i-Baba in the south. At that point, it focalizes on the Panjshir, on its right bank, 10 kilometers east of Charikar. It flows through the areas of Sheik Ali, Chinwari, Ghorband, and Surkh Parsa[8].The Ghorband gets numerous tributaries from both left and right, all bolstered basically by snowmelt in spring and summer. Its primary tributary is the Turkman, but the Salang River meets on the cleared out bank, and its valley is a critical get to course to the pass and towards the northern half of the nation. The Salang merges with the Ghorband in the region of Jabal Saraj [9].

### 2.1.1. Provincial Profile of Ghorband Sub-River Basin

The territory is situated 64 km to the north of Kabul. Charikar, Parwan's common capital, is one of the finest places in the nation for exchange. Inundated farmland of high quality and a distinctive horticulture with noteworthy cultivation and animal generation supplement conventional field crops. The topography of Parwan is composed of the Ghorband River and the Panjshir River. It is a mountainous province with the Kott-I-Baba Range in the southwest, the Panjshir Range in the north, and the Paghman Range in the southeast [10].

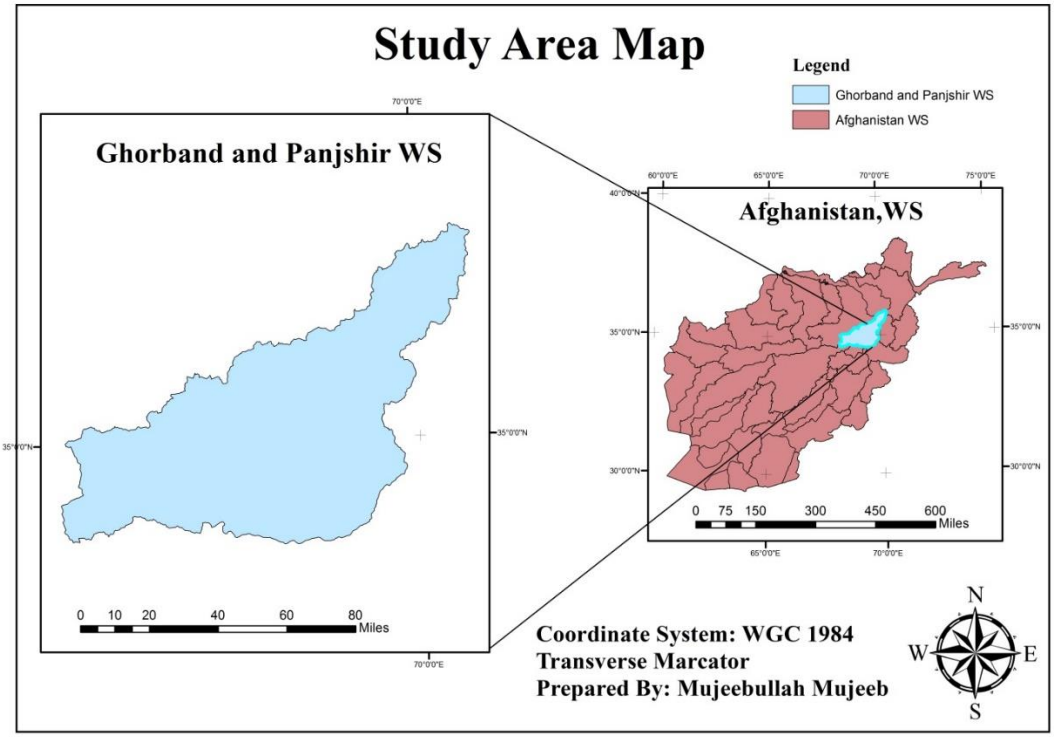



Figure 1: Study area map of Ghorband River Basin

River valleys are prominent and crops are rain fed around the Charikar district, which includes many vineyards and gardens. The majority of the territory is usable as rangeland, with some areas of intense irrigation [9]. In Ghorband and Shinwari districts, there is snow all year round. There are controversial views regarding the exact number of residents and total area of the province, but local sources are of the opinion that Parwan has a total area of 5,715 square kilometers with a total population of 600,000 individuals. Tajik, Pashtun, Hazara, Turkman, and Pashai tribes reside in the province in as many as 1,322 villages. The residents of Kohi Safi are Pashtun, Tajik in Salangare, Turkman, Tajik, Sadaat, and Hazara in Surkh Parsa, Shikh Ali Hazara. The rest of the districts have a mixed population of the tribes [11].

## 3. Climate

Precipitation and temperature are very heterogeneous in the Ghorband Sub-River Basin due to its large range in elevation. Based on the Köppen–Geiger climate classification scheme, the Kabul River Basin is mainly characterized by a mid-latitude steppe climate (Bsk, cold semi-arid climate), with some areas experiencing a Mediterranean-influenced subarctic climate [12].The Figure2 presents the mean monthly weather average for the

recent decade (2008–2022) mean monthly weather average, recorded at Ghorband Sub-River stations. The data was provided from the Afghanistan Meteorological Department [12].

Between 2008 and 2022, the annual minimum, maximum, and average temperatures have had a gradual decline. The maximum air temperature had its highest value of 36.4°C in 2008 and its lowest value of 31.8°C in 2013, whereas its value in 2022 stood at 38.1°C.

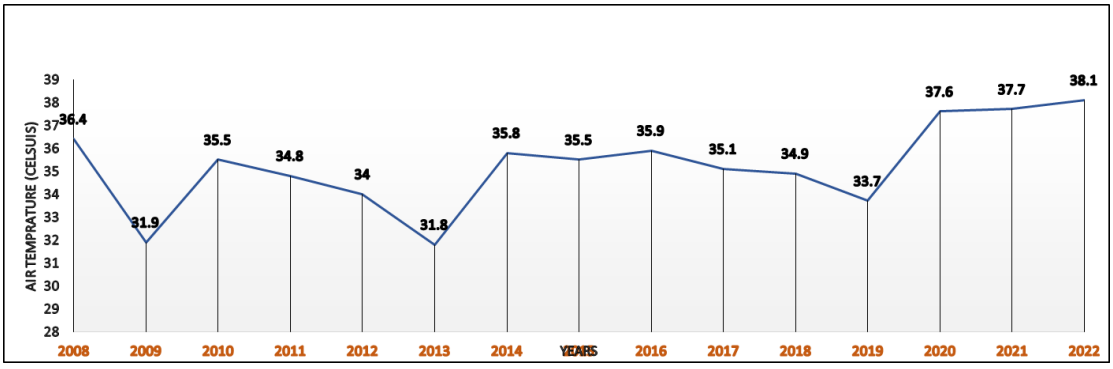



Figure 2: Max Annual Air Temperature (Pul-i-Ashawa station), (2008-2022)

In addition, the minimum air temperature had its highest value of 0.3 in 2008 and its lowest value of -9.3 in 2012.

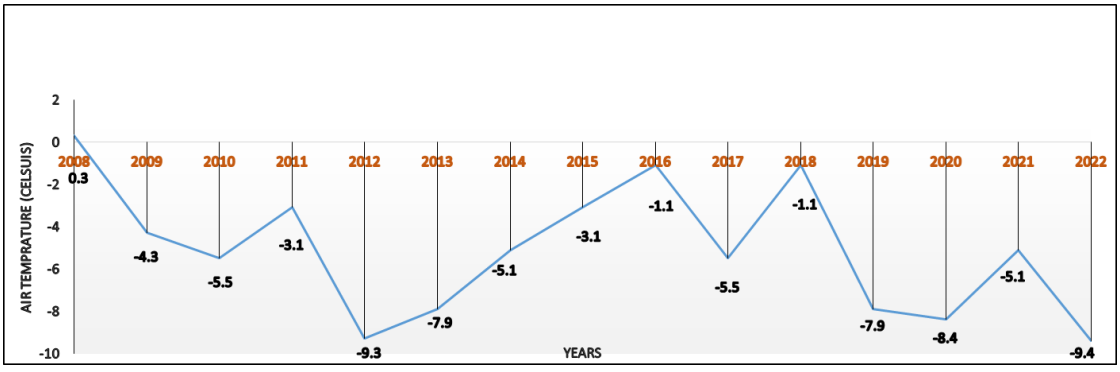



Figure 3: Min, Annual Air Temperature (Pul-i-Ashawa station), (2008-2022)

Besides, the average air temperature had its highest value of 19.5 °C in 2008 and its lowest value of 13.4°C in 2012, whereas its value in 2022 stood at 16.6°C, which indicates a gradual decline in the air temperature [13].

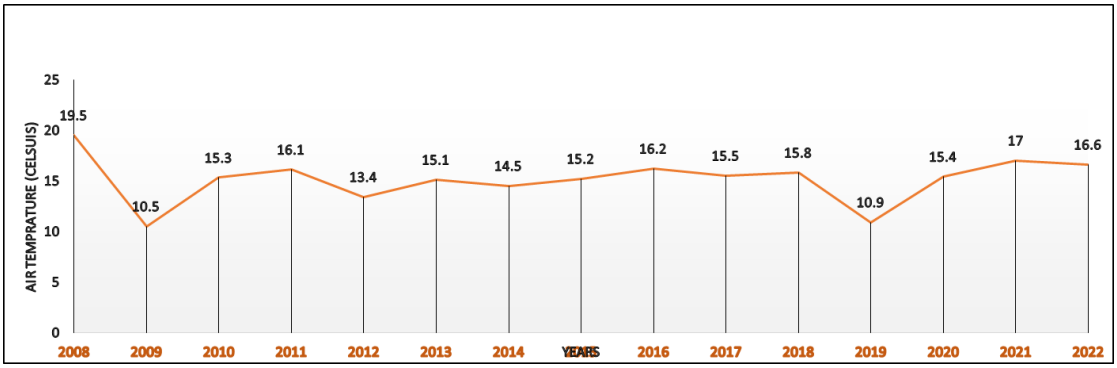



Figure4: Average annual air temperature (Pul-i-Ashawa station), (2008-2022)

## 4. Hydrology

The Ghorband and Panjshir Sub-River Basin and their tributaries are located in the north of the Kabul basin in Afghanistan. The upper part of the Ghorband River is characterized by high mountains and steep valleys. In the upper part, the Ghorband River is fed by rainfall, snow, and small glaciers. The output of this part of the Parvan plain catchment area is the branches of Golbahar, Shtel, Salang, Ghorband, and other The narrow strip of land covers the water. There are water measuring stations in this area: Shatel, Baghlallah, Pol-e Ashavah, and Shokhi. This sub-area's hydrological stations' average annual flow is presented [14]. Hydrological station Shokhi It is located almost at the exit of this part of the catchment. Most of the water required for consumption, irrigation, drinking and industry in the Parwan plain is from surface water sources of groundwater (deep wells, semi-deep, karezes and springs) provided. Up River, channels are generally narrow and deep and flow throughout the whole year. The runoff regimes are largely controlled by snow-melt, with high discharge from April to June and only close to glaciers in the upRiver parts of the catchment. The small glaciered area has significant influence on the flow regime [15].

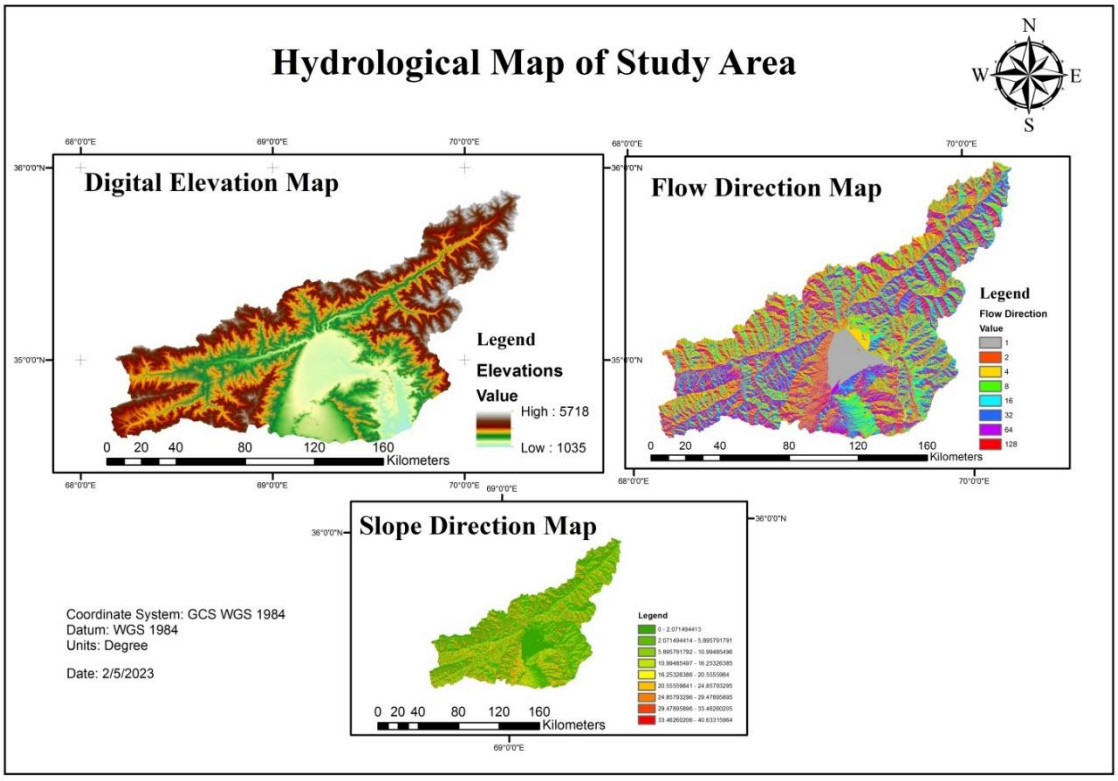



Figure 5: Hydrological map of Ghorband Sub-River Basin

## 5. Martials and Methods

Based on the data of Pul-i-Ashawa station of the Ghorband River acquired from the Ministry of Energy and Water (MEW), the hydrological regime of the Ghorband River can be assessed in two different time periods. This data is the Annual Mean Water Discharge ($m^3$/sec) of Pul-i-Ashawa Station between 1960-1980 and 2009-2022. In addition, the physical parameters of Ghorband River water were assessed using the available devices. The Ghorband and Panjshir sub-River basins include the northern heights of the Kabul basin, which has a discharge It is suitable and a large part of the current is required by the downRiver parts, including the flow. It provides access to Naghlo and Sorobi dams. Eastern parts of Panjshir in the range of Pamir Heights have permanent refrigerators and generally a wetter and colder diet. Compared to the western parts of Panjshir, The area of the Ghorband and Panjshir sub-basins is 12963.7 square kilometers, which becomes 1296370 hectares. The Ghorband and Panjshir sub-basins and their tributaries are located in the north of the Kabul basin. The output of this part of the Parvan plain catchment area is the branches of Golbahar, Shtel, Salang, Ghorband, and other The narrow strip of land covers the water [18].

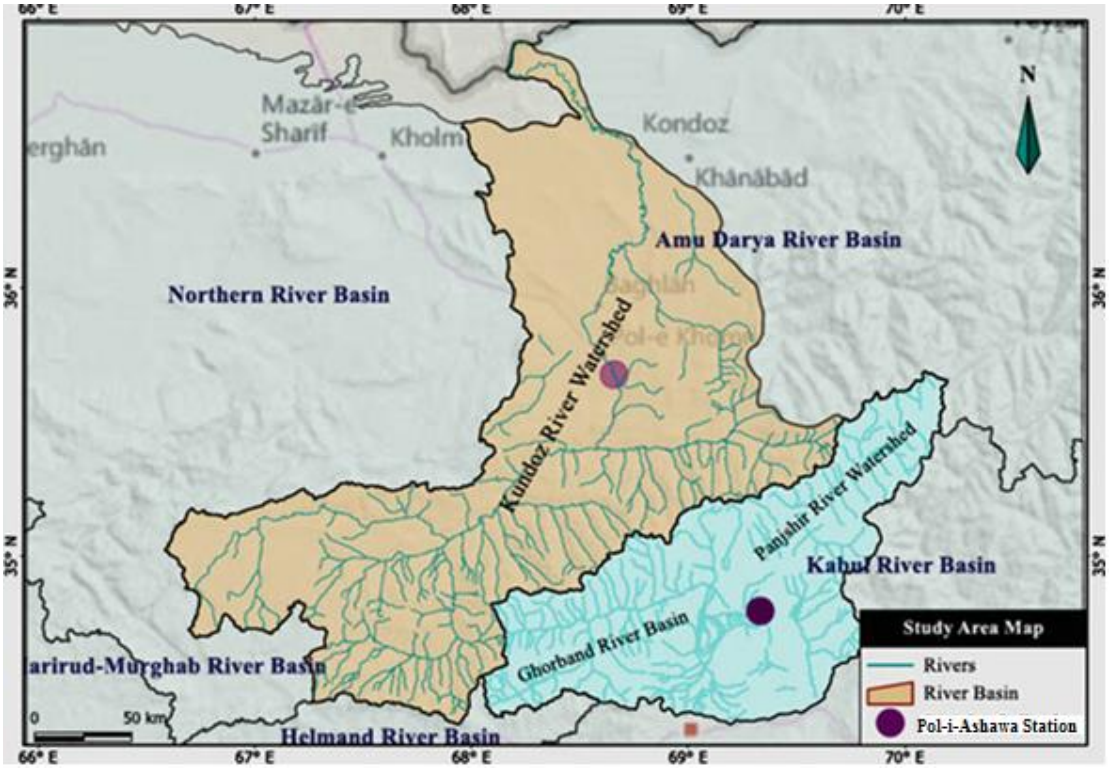



Figure 6: Location map of Pul-i-Ashawa station

### 5.2. Trend Analysis for Temperature, Precipitation and River Discharge

Linear trends in the time series were analyzed using Excel for trend analysis. It was chosen because it has higher power for non-normally distributed data, which is common in hydrological and meteorological data. Each element is compared with its successors and ranked as larger, equal, or smaller [19].

## 6. Results

### 6.1. Change in Precipitation and discharge (Figure 7).

Between 2009 and 2023, the most extreme precipitation had its most elevated esteem of 13 mm in 2012 and its reduced esteem of 1.86 mm in 2023, which appears to be extraordinary variances in one year after another. However, the total precipitation had its highest value of 619 mm in 2020 and its lowest value of 81 mm in 2023, the yearly add up to precipitation, in spite of the increment in most extreme precipitation, has had an incredible continuous decrease.

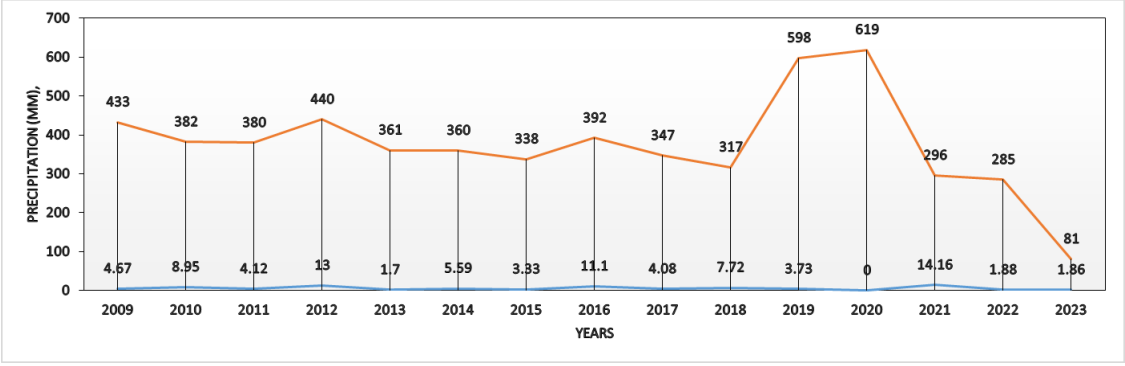



Figure 7: Max and total of precipitation from 2009-2023

As can be seen in the figure, the maximum annual water discharge has had an extremely fluctuating status. There has been a great deal of change in the amount of water discharge which indeed indicates an unstable status of hydrological regime. Specifically, the highest value of maximum annual discharge was 161$m^3$/sec in 1967, and the lowest value of maximum annual discharge was 63.2$m^3$/sec in 1974. But if we look at its overall trend, the maximum annual water discharge has declined considerably (Figure 7). In addition, the minimum annual water discharge value has also had a declining trend. Specifically, the highest value of minimum annual water discharge was 10.8$m^3$/sec in 1961 and its lowest value was 1$m^3$/sec in 1979. However, it has suddenly soured in 1980 to 11 $m^3$/sec which also shows the extremity and fluctuation.

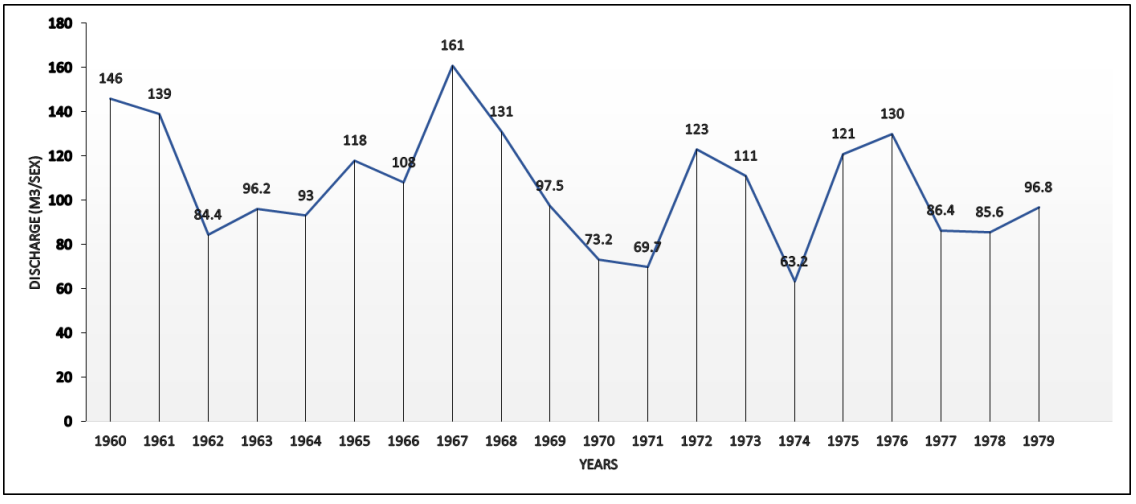



Figure 8: Max annual water discharge from 1960-1979

The mean annual water discharge had its highest value of 36.8$m^3$/sec in 1960 and its lowest value of 12.5$m^3$/sec in 1971.

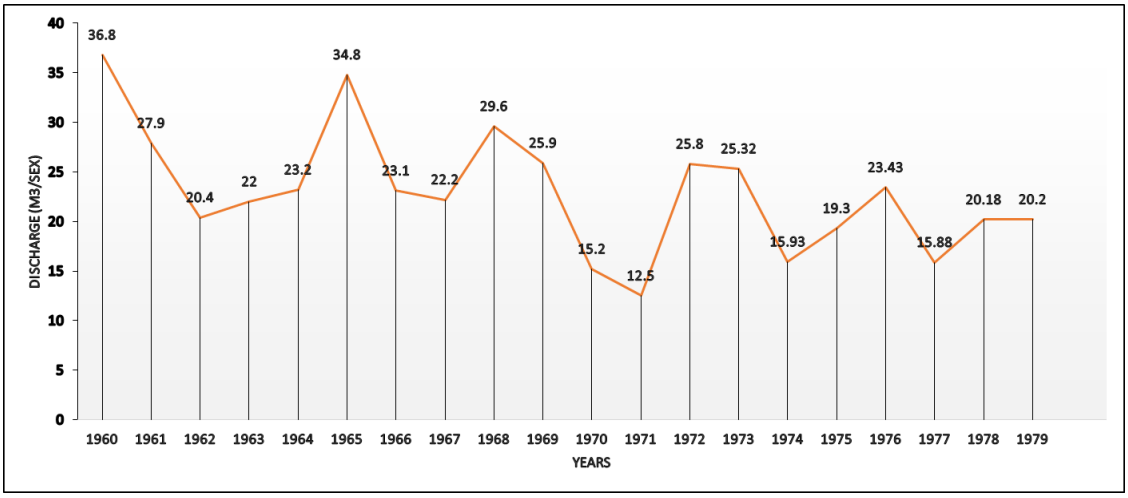



Figure 9: Mean annual water discharge from 1960-1979

As depicted, the overall trend of minimum annual water discharge also has a declining status. Coming to the mean annual water discharge, it also had a similar fluctuating status like maximum annual water discharge (Figure9).

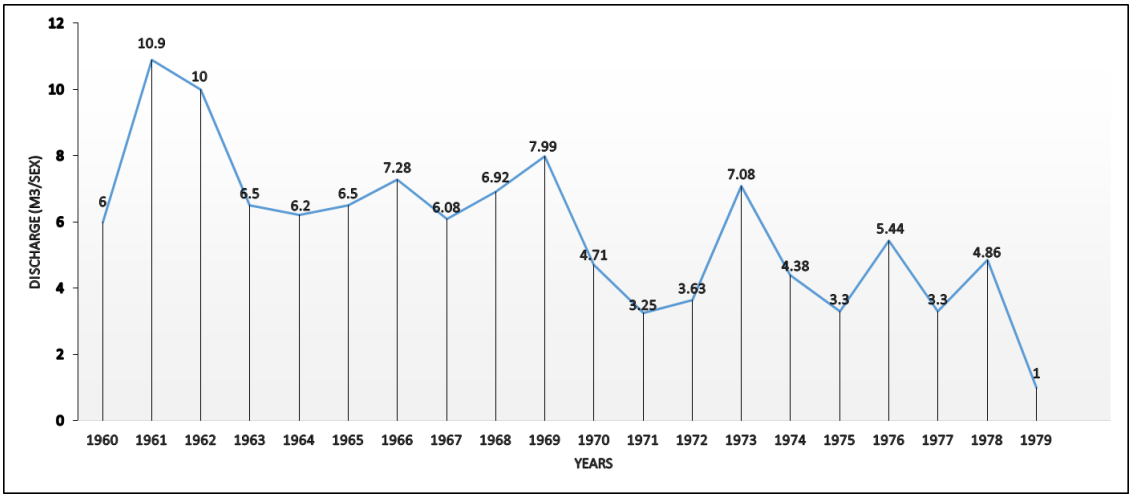



Figure 10: Min annual water discharge from 1960-1979

As can be seen, the mean annual water discharge also has a declining status in addition to the fluctuation (Figure 10).

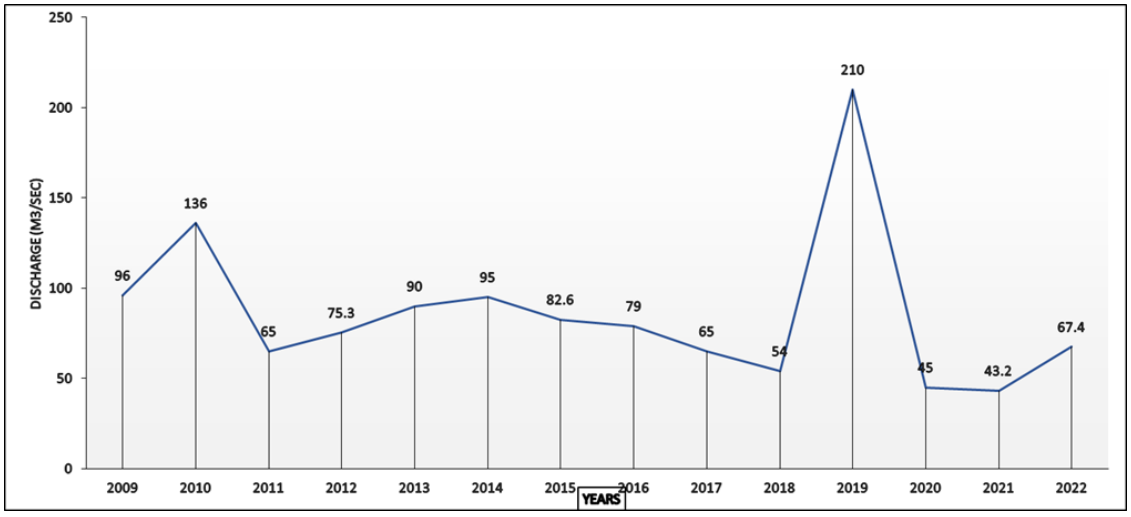



Figure 11: Max annual water Discharge from 2009-2022

As can be seen in figure 10 the maximum annual water discharge had a very dramatic and alarming decline between the years 2009 and 2022.

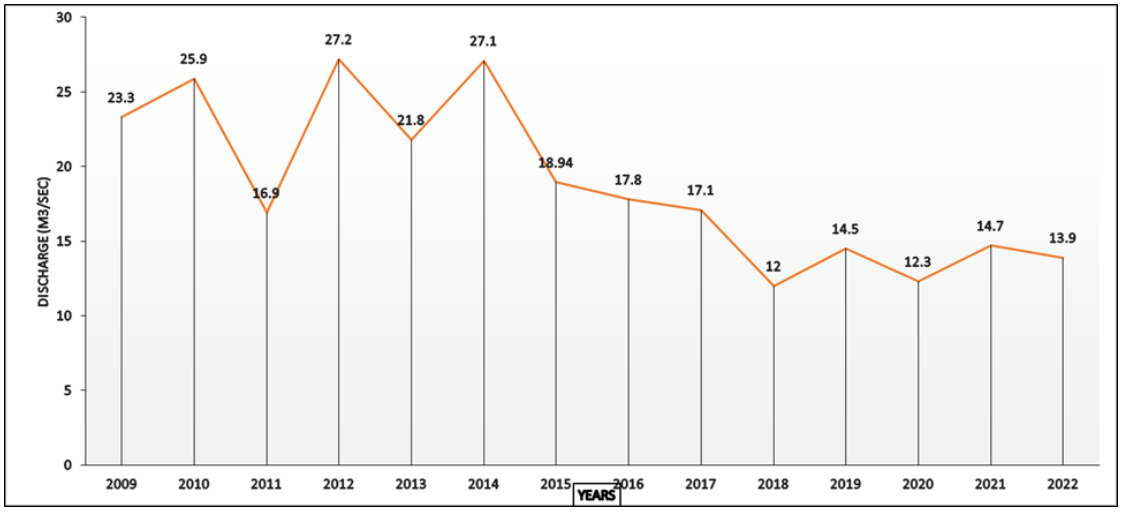



Figure 12: Mean annual water discharge from 2009-2022

The highest value of maximum annual water discharge was 210$m^3$/sec in 2019, followed by a drastic decline of 45$m^3$/sec in 2020. However, the lowest value of maximum annual water discharge stood at67.4 $m^3$/sec in 2022. It can be inferred from (Figure 12) that the maximum annual water discharge has declined continually, which is really concerning.

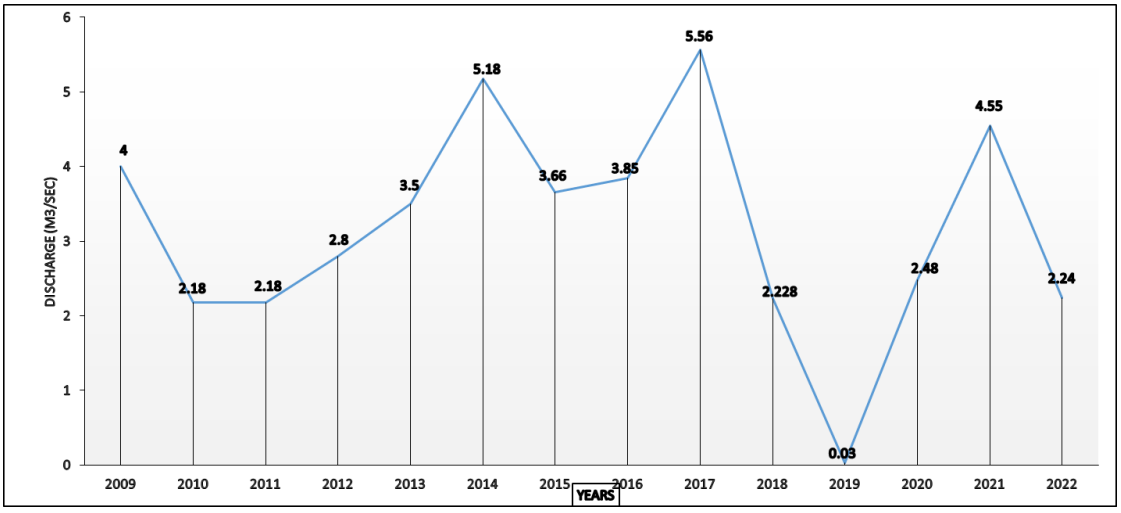



Figure 13: Min annual water discharge from 2009-2022

In addition, the minimum annual water discharge has also declined, as has the maximum annual water discharge (Figure 13).

## 6.2. Change in annual Run-off

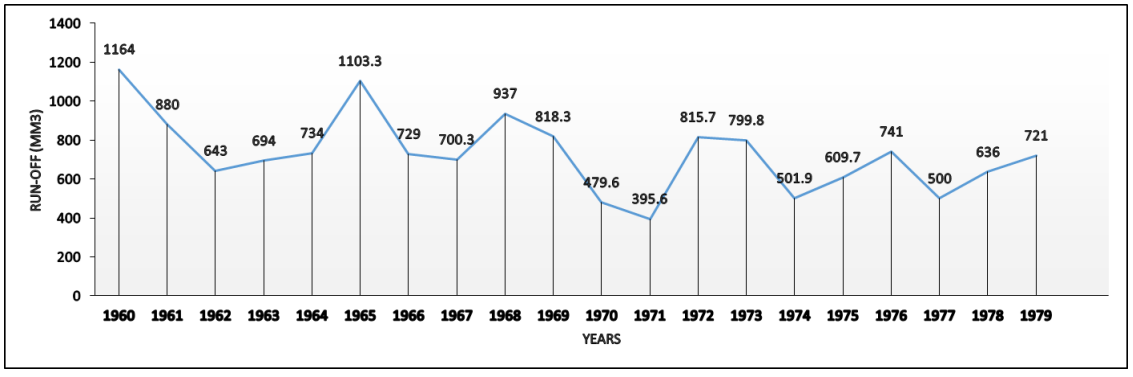



Figure 14: Annual run-off from 1960-1979

Between 1960 and 1979, the annual run-off had its highest value (Figure 14), 1164 MCM, in 1960 and its lowest value, 395.6 MCM, in 1971, whereas the mean run-off value in these years stood at 730.2 MCM.

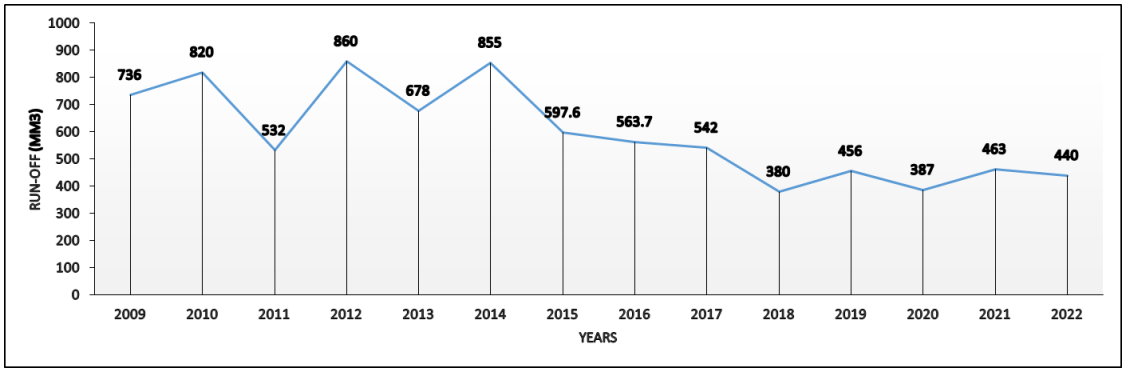



Figure 15: Annual run-off from 2009-2022

Between 2009 and 2022, the annual run-off had its highest value, 860 MCM, in 2012 and its lowest value, 380 MCM, in 2018, whereas the mean run-off value in these years stood at 440 MCM (Figure 15).

## 7. Discussion

In addition, the study explains that the yearly discharge of the Ghorband Sub-River basin is sufficient for developing the watershed if the water resources are managed in an integrated and sustainable way. The down part of the Ghorband Sub-River basin covers a wide area with large agriculture potential, for example through multiple cropping through irrigation. At the same time, the down River part of the Ghorband Sub-River basin is very vulnerable to flash floods and droughts, which affect the livelihood and socio-economic well-being of the community living within the watershed deeply. Therefore, integrated water resources management is key for agricultural development, livelihoods, and the local economy. Measures like reforestation could reduce the risk of flash floods and droughts. Other measures, which have proven their effectiveness for many catchments in a developing context, could include guidelines on best practices, the establishment of a River basin council, and adapted community-based participation approaches. Using approaches that involve communities directly in management and decision-making processes, we can collectively improve the socioeconomic and livelihoods of the people living in the Ghorband Sub-River basin. However, a comprehensive IWRM strategy is still missing for Afghanistan, and particularly for the Ghorband Sub-River basin. Therefore, it's hoped that the results of this study will contribute to informing sustainable water resource development and watershed management. In conclusion, this study argues for the establishment of an Integrated Water Resources Management Plan for the Ghorband Sub-River basin to trigger as for the mean annual water discharge, it also had a similar fluctuating status to the maximum annual water discharge. The mean annual water discharge had its highest value of

36.8m3/sec in 1960 and its lowest value of 12.5$m^3$/sec in 1971. As can be seen, the mean annual water discharge also has a declining status in addition to the fluctuation. In addition, the data from the recent years (2009–2022) of the Pul-i-Ashawa station indicated that the maximum annual water discharge had a very dramatic and alarming decline between the years 2009–2022. The highest value of maximum annual water discharge was 210$m^3$/sec in 2019, followed by a drastic decline of 43.2$m^3$/sec in 2021. However, the lowest value of maximum annual water discharge stood at 67.4$m^3$/sec in 2022. It can be inferred that the maximum annual water discharge has declined continually, which is really concerning. In addition, the minimum annual water discharge has also declined, as has the maximum annual water discharge. The minimum annual water discharge had its highest value of 5.56 $m^3$/sec in 2017 and its lowest value of 2.18 $m^3$/sec in 2011, whereas its value in 2022 stood at 2.34 $m^3$/sec.

However, the overall trend of the minimum annual water discharge depicts a fluctuating status between 2009 and 2022. Pertinently, if we look at the mean annual water discharge, it has a declining status as well. It had its highest value of 27.2$m^3$/sec in 2012 and its lowest value of 12$m^3$/sec in 2018, whereas its value in 2022 stood at 13.9. As can be seen, it has continually declined in the years mentioned. Pertinently, the data analyzed regarding the Pul-i-Ashawa station of the Ghorband River showed that the annual run-off of the Ghorband River has declined alarmingly. As the annual run-off had its highest value of 1164 MCM in 1960-1980, and based on the recent years' data, 2009–2022, it had its highest value of 860 MCM. It can easily be seen that there is a decline of 309 MCM in the highest value of the run-off, which is a really alarming reduction. And if we consider the mean run-off, there has been a decline of 73.8 MCM.

The data analyzed regarding Pul-i-Ashawa station on the Ghorband River in recent years (2008–2022) showed that the annual minimum, maximum, and average temperatures have also had a gradual increase. The maximum air temperature had its highest value of 36.4°C in 2008 and its lowest value of 31.8°C in 2013, whereas its value in 2022 stood at 38.1°C. In addition, the minimum air temperature had its highest value of 0.3 in 2008 and its lowest value of -9.3 in 2012. Besides, the average air temperature had its highest value of 19.5°C in 2008 and its lowest value of 13.4°C in 2012, whereas its value in 2022 stood at 16.6°C, which indicates a gradual decline in the air temperature, which indicates a gradual decline in the air temperature, but this decline is not as alarming as it is a small value of decline.

Moreover, the maximum precipitation had its highest value of 14.16 mm in 2021 and its lowest value of 1.7 mm in 2013, which shows extreme fluctuations in one year after another. However, the total precipitation had its highest value of 619 mm in 2020 and its lowest value of 285 mm in 2022, whereas the mean annual total precipitation stood at 285 mm. As can be seen, the annual total precipitation, despite the increase in

maximum precipitation, has had a great gradual decline, which is indeed really concerning.

## 8. Conclusions

The data analyzed regarding Pul-i-Ashawa station of the Ghorband River showed that the maximum annual water discharge has had an extremely fluctuating status between 1960 and 1980. There has been a great deal of change in the amount of water discharged, which indeed indicates an unstable status of the hydrological regime. Specifically, the highest value of maximum annual discharge was 161$m^3$/sec in 1967 and the lowest value of maximum annual discharge was 63.2$m^3$/sec in 1974. But if the overall trend looked by us, the maximum annual water discharge has declined considerably. In addition, the minimum annual water discharge value has also had a declining trend. Specifically, the highest value of minimum annual water discharge was 10.8m3/sec in 1961 and its lowest value was 1 $m^3$/sec in 1979. However, it suddenly soured in 1980 to 11 $m^3$/sec, which also shows the extremity and fluctuation. As depicted, the overall trend of minimum annual water discharge also has a declining status. Despite the potential limitations of this type of approach, this is a first step towards the assessment of future projected changes in surface water resources in ghorband Sub-River basin, which needs to be complemented by other studies comparing different hydrological and climate models.

## 9. Data Availability

The data used to support the findings of this research are available from the Corresponding author upon request.

## 10. Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

## 11. Acknowledgments

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