AFGHAN JOURNAL OF SCIENCE

CAPPADOCIA ACADEMY PUBLISHING

*Review article*

# A review of Hari Rud River Basin in Afghanistan

**Mostafa MOHAMMADI*, Abuzer ÇELEKLI**

Department of Biology, Faculty of Art and Science, Gaziantep University, 27310 Gaziantep, Turkey

*Correspondence: mostafa.035204@gmail.com

**Citation:** Mohammadi, M., & Çelekli, A. (2023). A review of Hari Rud River Basin in Afghanistan. *Afghan Journal of Science*, *1*, gak23102, 12p.

Received: 29.03.2023
Revised: 02.05.2023
Accepted: 17.06.2023
Published Online: 18.06.2023

## Abstract

The Harirud River Basin spans across Afghanistan, Iran, and Turkmenistan, making it a transboundary river basin. Cooperation among these countries is essential for effective water management, shared benefits, and conflict prevention. The Harirud River Basin holds significant importance due to its geographical, ecological, and geopolitical features. The Harirud River is a crucial water source in the region, providing irrigation for agricultural activities and supplying drinking water to local communities. The river's waters are used for irrigation in Afghanistan, Iran, and Turkmenistan, supporting agriculture and livelihoods in these countries. The Harirud River Basin encompasses diverse ecosystems, including wetlands, riparian forests, and desert areas. These habitats support a variety of plant and animal species, contributing to regional biodiversity. The Harirud River has the potential for hydropower generation, which can contribute to the region's energy needs. Constructing dams and utilizing the river's flow for electricity production can help meet the growing energy demands and promote economic development.

**Keywords:** Transboundary river basin, Herat, Geopolitical features



## Introduction

Afghanistan is a landlocked nation located in south-central Asia, with a total area of 652,000 km$^2$. Approximately 82% of Afghanistan's total land area is rangeland and barren land; less than 2% is covered by forests; and approximately 10% is arable. One-quarter of Afghan land is more than 2500 m above sea level. The major source of river flows in Afghanistan is rain and snowfall, and the Pamir and Hindukush highlands provide the initial potential for various river basins in the country (Habibi, 2014).

There are five river basins in Afghanistan: Amu Darya River, Helmand River, Kabul (Indus), Hari Rud River, and Northern River (Blind River system) basins. Among these, the Hari Rud River basin is located in western Afghanistan and is more developed than other basins in that region of the nation (Figure 1). The upper half of the basin is located in the Ghor province, at an elevation of 4000 m mean above sea level (MSL), while the bottom section is in the Herat province, at an elevation of 750 m above MSL. The basin area is around 3.9 million hectares, with a population of 0.46 million people (Adhikary et al., 2011).

Water resources are not distributed equally in Central Asia. While the majority of this water is used in the downstream provinces of

Kazakhstan, Uzbekistan, and Turkmenistan, the majority of renewable surface water is produced in the mountainous regions of Tajikistan, Afghanistan, and Kyrgyzstan (Sehring & Diebold, 2012). Transboundary rivers may have different names in different countries. The Hari Rud River, also known as the Tejen or Tedzhen River in Turkmenistan, flows near the city of Tedzhen (Sehring & Diebold, 2012; Wikipedia, 2022). It has a narrow valley with a gravelly bed in the upper stretch, while the river valley widens, flattens, and meanders significantly below the settlement of Obeh in the middle reach. The river forms part of the international border between Afghanistan and Iran in its lower stages before flowing into Turkmenistan and disappearing into the desert downstream (Adhikary et al., 2011).

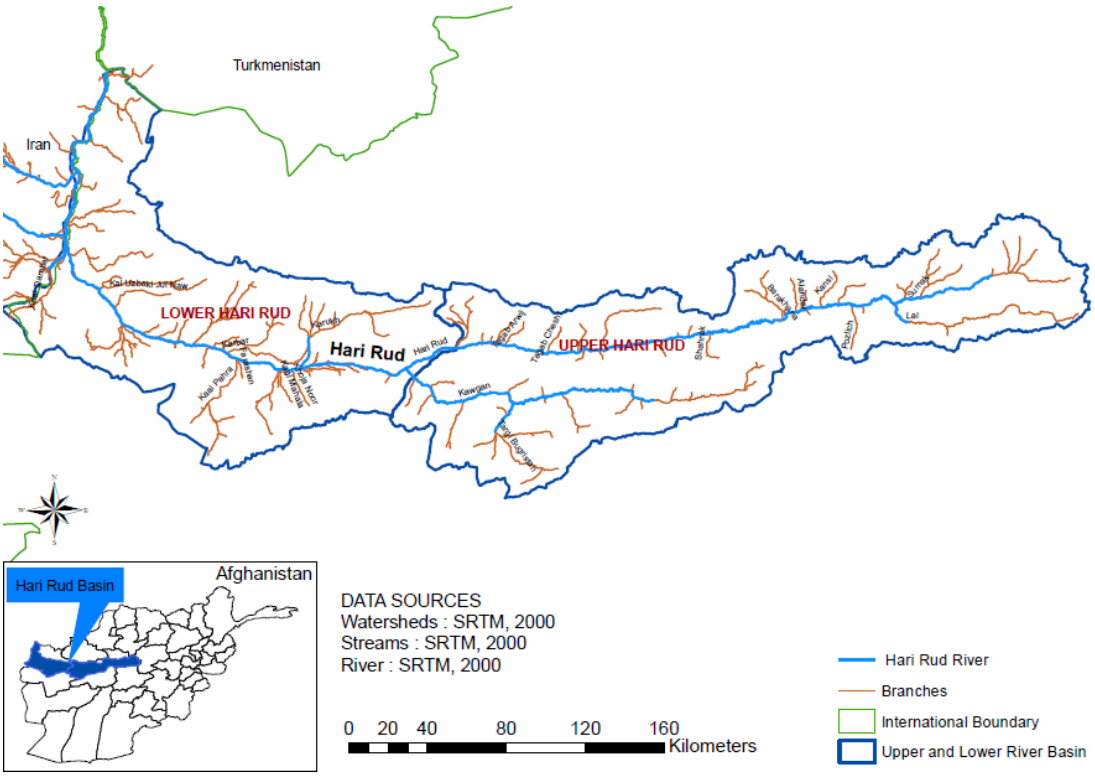


**Figure 1**. Hari Rud River and tributaries (ADB, 2014).

The Hari Rud River begins 250 km west of Kabul Province, with a length of 1124 km and a catchment area of 112,000 km$^2$ (Adhikary et al., 2011; Loodin & Warner, 2022). The river then runs through Herat before turning north, establishing a 160 km political boundary between Afghanistan and Iran. Then it extends to the north, establishing a 170 km political boundary between Turkmenistan and Iran until it reaches Turkmenistan's Karakum desert (Loodin and Warner, 2022). The Hari Rud's typical annual flow is around 55 m$^3$/s, although during a spring flood in 1939, the discharge reached 1090 m$^3$/s (Shroder and Ahmadzai, 2016). The main tributaries of the Hari Rud River are the Darya-i Lal and Kawgan rivers (Chokkakula & Rasouli, 2009).

The Hari Rud basin is divided into an upper and a lower part, as shown in Figure 1, which differ in terms of topography (ADB, 2014). The 1100-km-long river system accounts for approximately 12% of Afghanistan's water supplies and is dominant in the extensively irrigated districts surrounding Herat (Shroder & Ahmadzai, 2016). The available discharge in the Hari Rud River, which is mostly utilized for irrigation within the basin, is deficient in the summer and surplus in the spring. Because of this, groups that use water in the basin have changed how they get water for farming and irrigation to match how the river naturally flows (Adhikary et al., 2011).

The Hari Rud River basin in Afghanistan has an unstable environment in which the ecological flora and fauna have suffered as a result of years of civil war, severe drought, increased pressure on available water by the irrigation sector within the catchments, and a lack of attention to environmental impacts (Shroder & Ahmadzai, 2016; Adhikary et al., 2011). Water resources have made a significant contribution to the people's livelihood in the Hari Rud Basin (Nagheeby et al., 2019). The Hari Rud River irrigates the provinces of Ghor and Herat. Herat is one of Afghanistan's most progressive provinces, with historically dynamic leadership and strong trade relations with Iran. Herat is the second-largest province in terms of population and urbanization (after Kabul) (Chokkakula & Rasouli, 2009). Herat Province has a population of about 1.8 million people (Shakeri et al., 2022). A growing population, economic development, the effects of climate change, and poor water governance have all put significant pressure on the Hari Rud River's water resources (Nagheeby et al., 2019).

Unfortunately, no biological or ecological studies on this vital basin are currently underway. The main aim of this paper is to collect general information and introduce the Hari Rud River basin to local and international scientists (biologists) to raise awareness about the importance of this crucial basin and preserve its ecosystem. Encouraging professionals to focus their studies on this basin is also one of the goals of this research. It is critical to conduct scientific research on this basin in order to comprehend the complexities of this ecosystem and devise a strategy for its preservation.

## Material and Methods

This study appears to have collected articles from the Google Scholar website and various other sources, including the Ministry of Energy and Water of Afghanistan and international organizations working in the water, health, and agriculture sectors in the country. The goal of the study is to introduce the Hari Rud River basin and raise awareness about the importance of preserving its ecosystem, despite a lack of existing research on the ecology of the basin.

### *Geology*

Afghanistan is located along the great tectonic upheaval that produced the world's tallest mountain ranges, including the Himalaya, Karakoram, Pamirs, and Hindu Kush (USGS, 2005). The east-west oriented Hari Rud Valley and thus the route of the Hari Rud River are determined by the geological form of the Hari Rud fault, which traverses the area and splits into two branches. The geomorphology of the Hari Rud basin in its lower reaches can be defined as a Holocene river valley bordered by denudation, erosion, and accumulation reliefs. The Hari Rud River valley widens around 100 km east of Herat and is flanked on the north by prominent, south-facing mountain fronts (USGS, 2010). A USGS research (2010, cited in USGS, 2011) collected passive seismic data and showed that basin fill sediments along the lower Hari Rud might be as thick as 500 m, indicating significant groundwater supplies. Because the Hari Rud fault is tectonically active, seismological activity has frequently impacted the Hari Rud basin. The majority of areas along the Hari Rud River are classified as likely to sustain ‘major damage' in the event of an earthquake. Minor damage is predicted in the extended areas (ADB, 2014). Paleoproterozoic to Cenozoic rocks, particularly those of the Holocene period, are found in the Herat region basin. Holocene conglomerate and sandstone; alluvial fans and colluvium, particularly detrital sediments of gravel, sand, and clay (Holocene and late Pleistocene); conglomerate and sandstone (middle Pleistocene); loess (late Pleistocene); clay and siltstone (middle Miocene); clay and shale (Eocene); clay (Shakeri et al., 2022).

### *Ground Water Hari Rud Geosuture Seismotectonic Province*

Within the Hari Rud River valley graben within the Geosuture Block, two major aquifer types exist: thin alluvial sediment aquifers in narrow valleys that occur between steep valley walls of the mountain massif within the upper reaches of the Hari Rud River, including the area of

Chaghcharan city and the enclosed intermontane basin and valley aquifers of Herat (Shroder & Ahmadzai, 2016).

***Soils***

The International Institute for Applied Systems Analysis's Harmonized World Soil Database (HWSD) (IIASA, 2012) depicts the geographical distribution of soil types in the upper and lower Hari Rud basin. Lithosols, shallow, unproductive soils on usually steep slopes where only limited vegetation is feasible, are common in the basin's eastern and western portions. Calcic Yermosols (= Calcisols) near the basin's center require irrigation and are frequently well drained (ISRIC, 2013). The HWSD includes not only soil types but also physical soil layer properties (texture, drainage, accessible water capacity, depth, density, organic carbon) that are significant for hydrologic simulations (ADB, 2014).

***Ecological Importance***

According to archaeological research, the territory today known as Afghanistan was partially covered with deep forests rich with cedar as recently as 2000 BCE. Mountains, rivers, forests, farmland, and pastures are the backbone of the country's ecosystems and economy today (Saba, 2001). The natural ecology of the Hari Rud Basin is unstable (Adhikary et al., 2011). The natural terrain in the lower Hari Rud basin included wild pistachio and almond woods, as well as a high biodiversity, which have been extensively destroyed or depleted over the previous decades of conflict and heavy resource exploitation (ABD, 2002; Virgo et la., 2006; Qureshi, 2002; USGS, 2011). In the upstream portion of the Hari Rud basin, there is just one legally recognized protected area, the Bandi Amir national park, which is classified as a category II protected zone by the IUCN. The high upstream location suggests that this region won't be impacted by any changes in the flow of actions taken downstream (Shroder & Ahmadzai, 2016). According to Groombridge (1992), there are 3500 species of vascular plants, 30–35% of which are indigenous, as well as 5–10% of additional species that might be discovered in the future. According to our estimates, Afghanistan has roughly 5000 species, of which 25–30% are indigenous (Breckle, 2007). In the Hari Rud basin, rangeland made up the majority of the land cover as of 2010 (62%), followed by arid land (21%), and agricultural land (13%), according to the FAO's most recent analysis (FAO, 2013). The Hari Rud River basin's total population (5,020,000) and population density per km$^2$ are determined as 54 person/km$^2$ from three countries (Afghanistan, Iran, and Turkmenistan) (King and Sturtewagen, 2010). The Subhe Kabul newspaper claims the upper part of the Hari Rud River basin was home to many species of fish in the past but some of them disappeared due to drought, climate change, and illegal hunting (Saqi, 2020). Fortunately due to above adaptation, many fish species, such as *Rhinogobius similis, Cyprinion heratensis,* and *Alburnoides holciki,* can still be found in the basin (Egadary et al., 2018; Heyderi et al., 2020).

***Geosuture of Hari Rud Seismotectonic Province Ground-Water Geochemistry***

Analysis of well samples taken in the Hari Rud geosuture province reveals that the majority of the water is fresh, with a median TDS of 639 ppm and a range of 186 to 2368 ppm. Only 13-29% of the groundwater samples had levels of TDS, sulfate, salt, chloride, boron (as BO2), and fluoride (as F) that were higher than the WHO-recommended limits. As with the North Afghan Platform, this may have been due to evaporites or mixing with geothermal fluids (ADB, 2014).

***Climate***

The Hari Rud basin has a distinct climate, with cold winters and snowfall and a rainy spring with rising altitude. Monthly average climate parameters for the period 2002-2011 from ground-based stations of Meteorology Department are given on Table 1. With an asymmetrical regional distribution, the mean annual precipitation is 236 mm. Snowmelt, the primary source of the basin's groundwater and surface water for just two months

(February/March to April), is what causes runoff. The Hari Rud River experiences relatively low flows from August to February and very high flood levels from March to June. Between 1998 and 2002, the lower levels of the river completely dried up at least once in each of those years (Virgo et al., 2006). Farmers have adjusted their agricultural practices to this flow regime as the river's discharge is mostly utilized for irrigation (Adhikary et al., 2011). Another study found that Afghanistan has a dry to semi-dry environment with chilly winters and hot summers (USGS, 2010). In the Hari Rud valley, strong, hot, and dry north winds frequently occur in May and June (Virgo et al., 2006). The average annual rainfall in Herat is 310 mm; however, during the years of the 2000–2004 drought, there was only 180 mm of precipitation in the study region. The lower Hari Rud basin has monthly average temperatures ranging from 3 to 30 °C, while the higher Hari Rud basin has temperatures ranging from 12 to 19 (ADB, 2014). The annual temperature ranges from around 0 °C in December through February to maximums of over 30 °C in June and August (Virgo et al., 2006). According to the Uordo-Khan Research Farm, the mean wind speed in the basin (in Herat) was measured at its maximum (17 km/hr) in July and August and its minimum (6 km/hr) in December and January from 2002 to 2008. August has the maximum sunshine hours (11:35h), and December has the minimum (4:45h) (Basiri, 2009).

**Table 1.** Monthly average climate parameters for the period 2002-2011 from ground-based stations of (Meteorology Department). Precipitation (precip. mm/month), temperature (temp., °C) at Herat and scaled according to the atmospheric lapse rate (6.5°C/km) and altitude, potential evapotranspiration (mm/month) calculated through the Penman-Monteith formula.

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Nov-May | Jun-Oct | Annuan |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOWER HARI RUD STATIONS | | | | | | | | | | | | | | | |
| Herat | precip | 54 | 52 | 37 | 31 | 7 | 0 | 0 | 0 | 0 | 0 | 17 | 25 | 32 | 0 |
| | temp | 4 | 7 | 12 | 17 | 23 | 27 | 29 | 28 | 23 | 17 | 10 | 5 | 11 | 25 |
| | PET | 38 | 53 | 89 | 129 | 195 | 213 | 243 | 231 | 160 | 103 | 58 | 36 | 85 | 190 |
| Tirpul | precip | 33 | 32 | 39 | 16 | 8 | 0 | 1 | 0 | 0 | 0 | 18 | 14 | 23 | 0 |
| | temp | 3 | 6 | 12 | 17 | 23 | 27 | 29 | 27 | 23 | 16 | 10 | 5 | 11 | 24 |
| | PET | 40 | 55 | 92 | 132 | 200 | 219 | 251 | 239 | 165 | 107 | 60 | 38 | 88 | 196 |
| Zenda Jan | precip | 26 | 31 | 29 | 16 | 4 | 0 | 0 | 0 | 0 | 0 | 10 | 18 | 19 | 0 |
| | temp | 3 | 6 | 12 | 16 | 22 | 26 | 28 | 27 | 23 | 16 | 9 | 4 | 10 | 24 |
| | PET | 40 | 54 | 91 | 132 | 199 | 217 | 248 | 236 | 162 | 106 | 60 | 38 | 88 | 194 |
| UPPER HARI RUD STATIONS | | | | | | | | | | | | | | | |
| Chaghcharan | precip | 19 | 30 | 52 | 49 | 22 | 2 | 0 | 2 | 1 | 2 | 9 | 12 | 28 | 1 |
| | temp | -9 | -6 | 0 | 5 | 10 | 14 | 16 | 15 | 11 | 4 | -3 | -8 | -2 | 12 |
| | PET | 20 | 40 | 70 | 105 | 162 | 173 | 196 | 186 | 129 | 82 | 45 | 27 | 68 | 153 |

***Hari Rud and Herat Province***

Herat Province in western Afghanistan's lower Hari Rud basin is made up of about 1,000 badly drought-prone villages and is organized into 17 districts (Figure 2) (Bhattacharyya et al., 2004). Agriculture is the major source of livelihood. Other sources of income include the sale of cattle and other household possessions, the mortgage of land, and seasonal migration for employment to Herat or Iran (Iqbal et al., 2018). Herat Province is Afghanistan's second and third largest province in terms of both land area and population, with a population of approximately 1.8 million (Shakeri et al., 2022). The importance of Hari Rud for the Herat province is like the importance of vessels of blood vessels for the body.

***Salma Dam***

The Salma Dam is an earth-and-rockfill dam that provides irrigation and electricity to the Chishti Sharif District of Herat Province (Figure 3). It impounds the Hari River (Hari Rud) and has an active reservoir capacity of 560 million $m^3$. With the following design specifications for 42 MW energy generation, the dam consists of a power house, chute spillway, and switch yard: a 3.25-m-wide 6.72-m-long (63 $m^3/s$ discharge) power sluice, a 4.25 m-diameter penstock (2.46 m after trifurcation), a 15 $m^3/s$ irrigation sluice, and a 630 m-long, 8.5 m-diameter

diversion tunnel (Kumar et al., 2014). The dam, which is around 150 km east of Herat City, will be the largest in Afghanistan once it is fully constructed (Shroder & Ahmadzai, 2016).

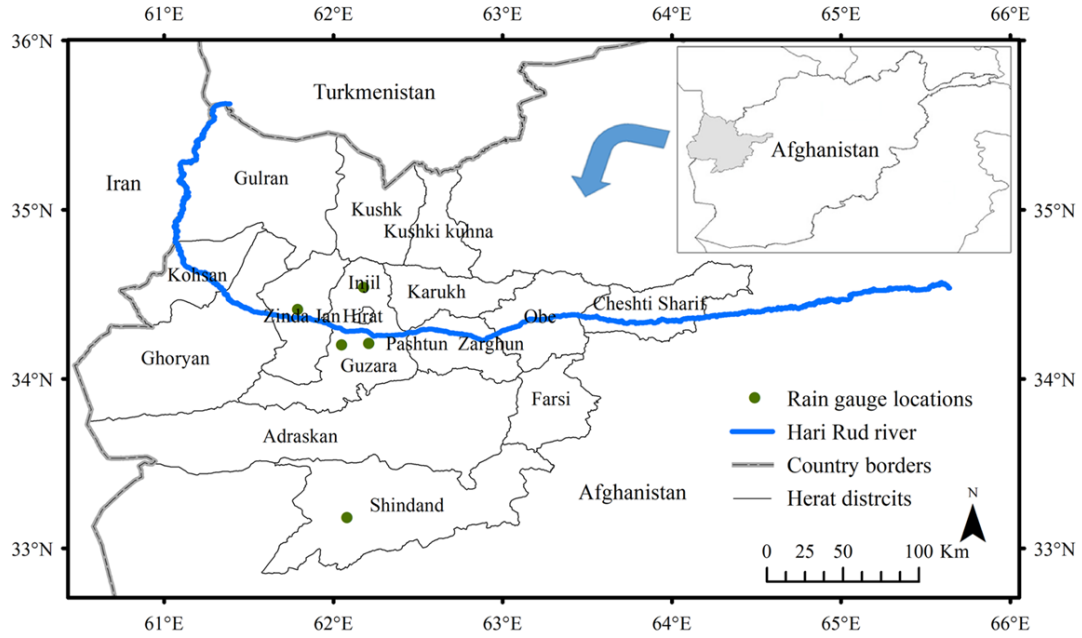


**Figure 2.** Districts of Herat province and Hari Rud River (Iqbal et al., 2018).

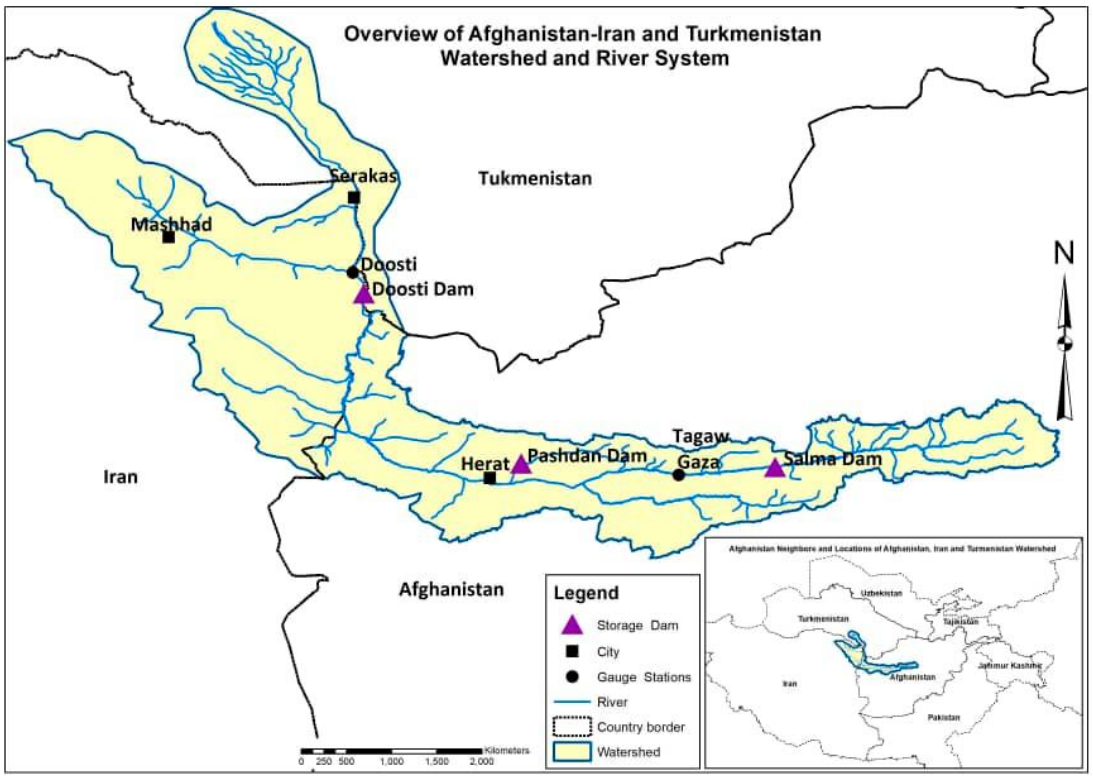


**Figure 3.** Location of dams in upstream and downstream of Hari Rud River Basin (Loodin and Warner, 2022)

### *Pashdan Dam*

A rock-fill dam with an intake structure, a powerhouse, weir head regulators, and right and left main canals is what is intended for the Pashdan dam (ADB, 2014). Early in 2011, work on the Pashdan Irrigation and Hydropower Dam project began (Figure 3). Although the project

was supposed to be finished in 2013, instability and the presence of the security crisis in the area caused it to continue until 2016, but in this year, it was stopped without completion. The construction phase was restarted in 2019 (Loodin & Warner, 2022). The earth-rock filled Pashdan Dam has a catchment area of 1847 $km^2$ and measures 42 m in height and 1100 m in length. The Pashdan Dam has a storage capacity of 54 MCM, can irrigate 13,000 hectares of land, and will be able to generate 2 megawatts of electricity once two turbines are installed (Omar, 2022).

***Doosti Dam***

The dam is being built in Iran's northern Khorasan Province, 260 km northeast of Mashhad and 75 km south of Sarakhs city. The dam's latitude and longitude are 75/350° North and 9/610° East, respectively (longitude). It is a soil dam with a silicate clay core on argillite stones, with dimensions of height equal to 79 m, dam crown length of 655 m, crown width of 15 m, and storage capacity of roughly 1250.000.000 $m^3$ (Fathi & Golestani, 2018). The dam is built on the Hari Rud River, which flows from Afghanistan's central highlands and eventually arrives at the Doosti Dam (Figure 3) after roughly 690 km of stones (Yargholi and Azimi, 2021). But when they jointly built the Doosti Dam across the lower parts of the river separating their two nations, neither they nor Turkmenistan tried to consult with Afghanistan (Shroder & Ahmadzai, 2016). This dam's primary goals are to give drinking water to Mashhad, Iran's second-largest city, agricultural water supplies for both Iran and Turkmenistan, regulate floods, stop bank erosion, and build a hydroelectric power plant (under design) (Yargholi & Azimi, 2021).

***Agriculture***

Almost 7000 years ago, the ancestors of Afghanistan's people, employing still-relevant and in-use technologies, introduced and established sound agricultural methods (Saba, 2001). In 2012 nearly 60% of Afghan workers were working in the agricultural sector, which meant that 80% of households depended mostly or partially on income from the sector (ILO, 2012). According to studies, about 5,020,000 people benefit from this basin. In the Hari Rud basin, agriculture is the primary industry of employment. Cereals, vegetables, fruits, nuts, and fodder are the most common products in the basin. Herat's grape and Badghis's pistachio are famous throughout the country. Only two to three percent of the basin's area is irrigated, and a significant percentage of it is made up of rangelands. The most agricultural lands in Herat and Ghor provinces are irrigated by the Hari Rud River basin. In the basin, three types of irrigation systems are encountered: traditional canals that acquire water from a nearby stream or spring, Karezes, and wells. Salma and Doosti dams are constructed on the Hari Rud River, and the work on the Pashdan dam continues. Climate changes, low annual precipitation (236 mm), drought, war in the country, poor management, and lack of information and scientific studies of the basin have caused it to become an unstable ecological environment. Unfortunately, there has been no scientific study about the definition of flora and fauna, the determination of species, or the ecology of this major basin until now. It is crucial that scientists do something and pay attention to the basin. Otherwise, endemic species will go extinct without our knowing it. It has been observed that incredibly significant investigations should be conducted in order to determine the pressures on the basin of the Hari Rud River and the water quality in various areas. Also, in the Hari Rud basin, agriculture is the primary industry of employment (ADB, 2014). The irrigation system's architecture and management of the accompanying water flows serve as a crucial foundation for agricultural productivity in the basin. Only two to three percent of the basin's area is irrigated, and a significant percentage of it is made up of rangelands. The area used for single or double crops is determined by the flow of the Hari Rud River (Chokkakula & Rasouli, 2009). Cereal crops provide for the majority of agricultural output in the provinces (444,137 tons annually), followed by horticultural crops such as vegetables (160,744 tons annually), fruit and nuts (77,616 tons annually), and fodder (77,770 tons per year) (ADB, 2014).

***Irrigation and Techniques***

99% of the water utilized in Afghanistan is for agricultural irrigation (ABD, 2002). The methods for scheduling irrigation are still mostly focused on a farmer's knowledge (traditional irrigation) to obtain the maximum amount of water. As a result, farmers' current irrigation practices tend to either over-irrigate or provide an excessive lack of water, which results in an inadequate environment for agriculture (Basiri, 2009). In the Hari Rud basin, three types of irrigation systems are encountered, namely: traditional canals that acquire water from a nearby stream or spring, Karezes, and wells.

***Canal***

Regarding traditional canals, their quantity, area coverage, and socio-institutional features of irrigation management, the Hari Rud basin is one of the richest basins in Afghanistan (Chokkakula & Rasouli, 2009). These canals are thought to now irrigate around 125,932 hectares of irrigated farmland, which were separated into 7 zones for the purpose of water resources modeling, according to a GIS evaluation of the irrigated area of the Hari Rud Basin.

***Karez***

In Afghanistan, irrigation water supply is usually provided through a Karez, an ancient water conveyance system. Figure 4 depicts and describes a Karez system. It consists of a number of vertical access shafts that resemble wells (Karez shafts), several of which are drilled well below the nearby groundwater table at the tunnel's upstream end to allow water to flow through the tunnel. Typically, Karezes have grown in places without access to surface water. Water from a Karez is utilized for agriculture as well as household water supply, but many of them are currently inoperable owing to recurring draughts, an increase in the number of deep tube wells, and low maintenance involvement (MEW, 2008: Qureshi, 2002). According to MEW-data, Herat's 368 Karezes in the Hari Rud basin irrigate approximately 18,000 hectares of agricultural land. In the area of the Ghor Province, it is said that Karezes is used to irrigate 710 acres of land there (Qureshi, 2002).

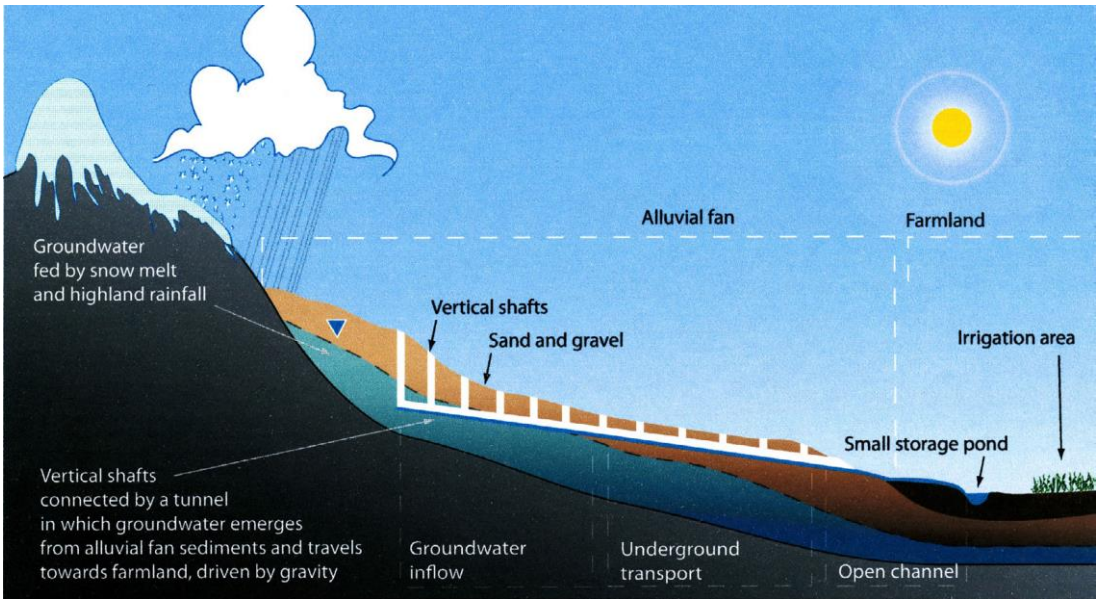


**Figure 4.** A Karez system (Shroder and Ahmadzai, 2016).

***Wells (Groundwater)***

In the Hari Rud basin, surface irrigation is typically utilized in combination with well (groundwater) irrigation, especially during the dry season when surface water supplies are few (Figure 5). The most common method for obtaining groundwater for irrigation is through dug wells with motor-driven pumps. Farmers have, however, recently begun putting in shallow and deep tube wells. These are often located in the command regions of conventional canals since groundwater irrigation is most frequently utilized in combination with traditional canals (surface irrigation). There are thought to be 263 shallow tube wells used for irrigation in the Ghor Province, irrigating 368 acres (Qureshi, 2002). Similarly, DACAAR (an Afghan NGO) estimates that the Herat province of the Hari Rud basin had roughly 5,513 wells.

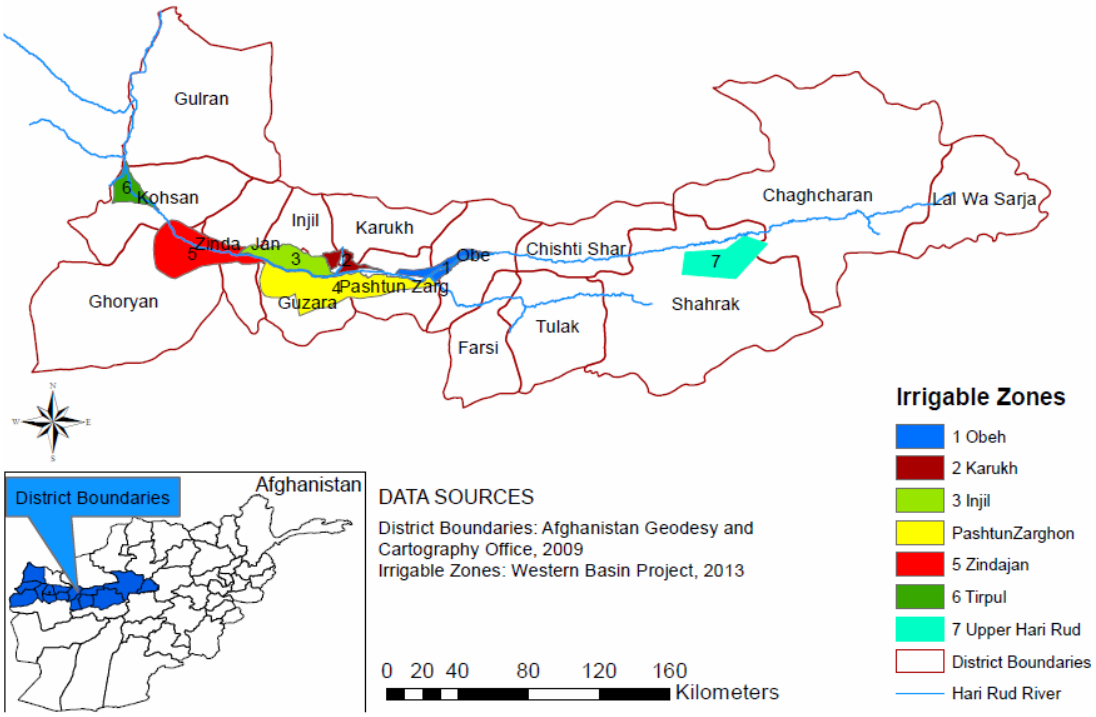


**Figure 5.** Irrigable zones vs. district boundaries (ADB, 2014).

### *Flood Risk*

Flooding happens often in the basin of the Hari Rud River. Along the Hari Rud River in Ghor, there are major flood risk zones. The danger of flooding is quite minimal in the Herat Province along the lower Hari Rud River. The months of March through June often have the highest flooding risk. Flash floods are brought on by precipitation and/or snowmelt, and they are made worse by the significant deforestation that has occurred over the past few decades (IACP, 2013). In 1997, in the Heri Rud valley in western Afghanistan thousands of acres of farmland were flooded and destroyed (Saba, 2001). Between 1998 and 2002, the river's lower levels completely dried up at least once in each of those years. Since most of the river's flow is used for irrigation, farmers have changed how they farm to fit this flow pattern. The areas closest to the river and those where people live in substandard homes adjacent to steep mountain slopes have the largest risk of harm (IACP, 2013).

## Conclusion

The Hari Rud River Basin is one of the important basins of Afghanistan, located in the south-western part of the country. The river was divided into upper and lower parts. The upper section flows into Ghor province, while the lower section flows into Herat province, forming the border between Afghanistan and Iran, as well as Iran and Turkmenistan. This river basin

gives life to Ghor and Herat provinces, like vessels in the body. This part of the country, with its dry and semi-dry climate, is crucially dependent on the flow of water in the Hari Rud River. Geological studies have shown the geomorphology of the Hari Rud basin in its lower reaches can be defined as a Holocene river valley bordered by denudation, erosion, and accumulation reliefs. Many studies depict the geographical distribution of soil types in the upper and lower Hari Rud basins. Lithosols, shallow, unproductive soils on usually steep slopes where only limited vegetation is feasible, are common in the basin's eastern and western portions.

The river basin holds geopolitical significance due to its location and the interactions between the countries it spans. The management of water resources in the Harirud River Basin can influence diplomatic relations, regional stability, and cooperation among Afghanistan, Iran, and Turkmenistan. Resolving any disputes or conflicts related to water usage can contribute to peaceful relations and regional integration.

The natural ecology of the Hari Rud Basin is unstable. The natural terrain in the lower Hari Rud basin included wild pistachio and almond woods, as well as a high biodiversity, all of, which have been extensively destroyed or depleted over the previous decades of conflict and heavy resource exploitation. In the upstream portion of the Hari Rud basin, there is just one legally recognized protected area, the Bandi Amir national park, which is classified as a category II protected zone by the IUCN.

***Acknowledgments:*** The authors also thank the anonymous reviewers for their helpful comments and suggestions.

***Funding:*** This study has no financial support.

***Data Availability Statement:*** The data that support the findings of this study are available from the corresponding author upon reasonable request.

***Conflicts of Interest:*** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**References**

ADB. (2002). *Afghanistan's Environment in Transition*. 789: 11-14 http://www.nawabi.de/chemical/afghan_Envir_trans.

Adhikary, S. K., Das, S. K., Atef, S. S., Das, Gupta, A., & Babel, M. S. (2011). *Simulating impacts of EFR consideration on reservoir operation policy and irrigation management in the Hari Rod River Basin, Afghanistan*. 19th International Congress on Modelling and Simulation, Perth, Australia, 12–16 December 2011. 14428: 4086-4087 http://mssanz.org.au/modsim2011

Asian Development Bank (ADB). (2014). *Hari Rud River Basin Master Plan*. unpublished document. P: 38-60.

Basiri, A. F. (2009). *Options for Improving Irrigation Water Allocation and Use: A Case Study in Hari Rod River Basin, Afghanistan*. A thesis submitted in partial fulfillment of the requirements for the Degree of Master of Engineering in Water Engineering and Management. A thesis submitted in partial fulfillment of the requirements for the Degree of Master of Engineering in Water Engineering and Management. P: 6,32.

Bhattacharyya, K., Azizi, P. M., Shobair, S. S., & Mohsini, M. Y. (2004). *Drought impacts and potential for their mitigation in Southern and Western Afghanistan*. Working Paper, Drought Series Colombo, Sri Lanka: International Water Management Institute, 91(5), 5-6. http://www.iwmi.cgiar.org/Publications/Working_Papers/working/WOR91

Breckle, S. W. (2007). *Flora and Vegetation of Afghanistan*. Department of Ecology, University of Bielefeld, Wasserfuhr. 196: 156. ISSN 1864-3191.

Chokkakula, S., & Rasouli, Q. (2009). Interrogating Irrigation Inequities: Canal Irrigation Systems in Injil District, Herat. AREU publication. 4: 3-4.

Egadary, S., Kelari Ebrahimi, S., Ashrafi, S., & Jalili, P. (2018). Population variation of *Capoeta heratensis* in Hari River and Dasht-e Kavir basins using geometric morphometric technique. *Journal of Aquaculture Sciences, 6*(5): 36-37.

FAO. (2013*). Irrigation in Central Asia in figures*. In AQUASTAT Survey Water Reports 39, Frenken, K., Ed., FAO: 87-95. Rome, Italy,2013, E-ISBN 978-92-5-106316-3.

Fathi, E., & Golestani, M. (2018). *Instrumentation Performance Results in Earth Dams and Comparing with Numerical Analysis: A Case Study on Doosti Earth Dam in Iran*. EJGE. 23: 271-272 Postal Code: 156677535.

Groombridge, B. (1992). *Global Biodiversity-Status of the earth's living resources*. Chapman and Hall, London, 585pp.

Habib, H. (2014). Water related problems in Afghanistan. *International Journal of Educational Studies. 137*(144): 137-138.

Heyderi, A., Sattari, M., Mousavi, H., & Alavi Yeganeh, M. S. (2019). *مقایسه ای ریخت شناسی دو جمیعت گاو ماهی Rhinogobius similis* Gill, *دریاچه ای در حوزه آبریز هریرود با استفاده از سیستم تراس پژوهش های کاربردی ماهی, نشریه شناسی کاربردی*. 98: 144-145. http://jair.gonbad.ac.ir

IACP. (2013). *Western Region-Floods Contingency Plan*. Humanitarian Regional Team. Version 5, March 2013. http://afg.humanitarianresponse.info/sites/default/files/IACP%20Floods%20WR%20Feb2013%20_v5.

IIASA. (2012). *Harmonized World Soil Database*. Version 1.2, FAO/IIASA/ISRIC/ISS-CAS/JRC, AO, Rome, Italy and IIASA, Laxenburg, Austria.

Iqbal, M. W., Donjadee, S., Kwanyuen, B., & Liu, S. Y. (2018). Farmers' perceptions of and adaptations to drought in Herat Province, Afghanistan. *Journal of Mountain Science, 15*(8), 1743-1744. https://doi.org/10.1007/s11629-017-4750-z.

ISRIC. (2013). *World Soil Information*. http://www.isric.org/isric/webdocs/docs//major_soils_of_the_world/set7/cl/calcisol.

King, M., & Sturtewagen, B. (2010). *Making the Most of Afghanistan's River Basins Opportunities for Regional Cooperation*. The East West Institute. 11 East 26th Street, 20th Floor. New York. P: 5-6.

Kumar, R., Prasad, N., Mahure, V., Sharma, P., Gupta, L., & Ratnam, M. (2014). Concreting at Low Ambient Temperatures at Salma Dam Project Afghanistan—A Case Study. *International Journal of Emerging Technology and Advanced Engineering, 4*(2), 917-918.

Loodin N., & Warner J. (2022). A Review of Hydro-Hegemonic Dynamics on the Transboundary Hari Rud River Basin: 2001–Present. *Water, 14*, 3442: 5-6.

MEW. 2008. Water Sector Strategy of Afghanistan, Islamic Republic of Afghanistan, MEW Kabul. http://moec.gov.af/Content/files/Water%20Sector%20Strategy%20-%20English

Nagheeby, M., Piri, D. M., & Faure M. (2019). The Legitimacy of Dam Development in International Watercourses: A Case Study of the Hari Rud River Basin. *Transnational Environmental Law, 8*(2), 247–278. https://doi.org/10.1017/s2047102519000128

Omar. (2022). With Construction Halted, Herat's Pashdan Dam Faces Uncertain Future. Salaam Times. 18 January 2022. https://afghanistan.asianews.com/en_GB/articles/cnmi_st/features/2022/01/18/feature-01

Qureshi, A. S. (2002). *Water Resources Management in Afghanistan*. The Issues and Options. IWMI. 14: 11-20 publication. http://www.afghaneic.net/library/hydrological%20surveys/wor49

Saba, D, S. (2001). Afghanistan: Environmental degradation in a fragile ecological setting. *The International Journal of Sustainable Development & World Ecology. 8*(4), 279-289. https://doi.org/10.1080/13504500109470086

Saqi, N. (2020). *Upper Hrirud Fishes*. (Kabul's Morning Newspaper). subhekabul.com/%d9%85upper-herring-fish/

Sehring, J., & Diebold, A. (2012). *From the Glaciers to The Aral Sea Water Unites*. Berlin, 10117. ISBN, 978-3-89794-800-6. www.trescher-verlag.de

Shakeri, A., Hosseini, H., Rastegari, Mehr, M., & Dashti Barmaki, M. (2022). Groundwater quality evaluation using water quality index (WQI) and human health risk (HHR) assessment in Herat aquifer, west Afghanistan, Human and Ecological Risk Assessment: *An International Journal, 28*(7), 711-733. https://doi.org/10.1080/10807039.2022.2075316

Shroder, J. F., & Ahmadzai, S. J. (2016). *Transboundary Water Resources in Afghanistan*. Candice Janco. P: 37-455. ISBN: 978-0-12-801886-6

USGS. (2010). Geologic and Mineral Resource Map of Afghanistan. http://pubs.usgs.gov/of/2006/1038/

USGS. (2011). Summaries of Important Areas for Mineral Investment and Production Opportunities of Non-fuel Minerals in Afghanistan. Open File Report. USGS Afghanistan Project Product No.199. http://afghanistan.cr.usgs.gov/nonfuel-report

USGS. (2005). Seismotectonic Map of Afghanistan, with Annotated Bibliography. http://pubs.usgs.gov/of/2005/1264/

Virgo, K. J., Aslami, M. H., Ahmed, B. (2006). Participatory Watershed Management: Examples from Herat, Western Afghanistan. *Proceedings of World Association of Soil and Water Conservation*, P1-8, 65-81.

Wikipedia. 2022. Hari (Afghanistan). https://en.wikipedia.org/w/index.php?title=Hari_(Afghanistan)&oldid=1114614513

Yargholi, B., & Azimi, M. M. (2021). *Determine Environmental Risks to Provide Water Quality Remedies (Case Study: Doosti Dam Reservoir)*. 5th Asia-Pacific Group - International Symposium on Water and Dams. P: 24-27 February 2021, New Delhi, India.