Water Balance Assessment in Three Northern (Kunduz, Balkh & Jawzjan) Provinces of Afghanistan

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Abstract

Water is continually a limited resource that needs to be harnessed so as to meet the growing basic demand for development events. It is serious to social and economic progress and often directly affects the activities of the society. For sustainable development of water resource management, there is much need of conducting regular studies, this is due to the fast growing socio-economic activities, which has impact to this valuable resource. Water balance assessment assists to be vital tool for any extra hydrological study. Water balance assessment study allows estimation of water resource and their change under the influence of anthropogenic activities but also it assists the projecting of the concerns of artificial changes in the water body like lake, stream and groundwater basins. The requirement for clear understanding of hydrologic system becomes very crucial because it forms the entrance for providing information for water resource managements. The main objective of this study is to estimate various water balance components in three northern (Kunduz, Balkh & Jawzjan) provinces of Afghanistan.

Keywords: Water Balance; Precipitation; Evaporation and Discharge

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Introduction

Population growing, global warming, and enlarged demand for water have caused global alarm about increasing water scarcity. Water availability and distribution are inadequate both in time and space, with 97.5% of the world's water existence salty and found in the oceans, and only 2.5% is considered fresh. Freshwater locked up in glaciers accounts for 68.7%, whereas groundwater, surface water, and other fresh fluids account for 30.1%, 0.9 percent, and 0.8%, respectively (Greenhalgh et al., 2004). Globally, freshwater denotes only 3% of existing water resources on the earth, of which 0.3% is accessible for human use (McGlade et al., 2012). At the same time, spatially and temporally, water is not equally distributed and yet continues to play a vital role in our daily upkeep. It is a resource not only for domestic use but also for supporting environmental systems.In the last decades, water issue has reserved new vision not only from the specialists and engineers only but also all stakeholders who articulate the claims, values and their common interests around water management issues. (Molle, 2009) This is because high level of water problems increases the frequency of claims between various stakeholders and endangers their security and even the threat on military conflict between the neighboring countries (Hensel et al., 2006). Nevertheless, in current year, industrial development, urbanization, and increase in agricultural production, has led to scientific approach to water resource planning, development and management. Number of great level groups like UN have taken initiatives to statement the water matters and increasingly carrying out activities on the quantity and quality of global/regional water resources, trans-boundary water resources management, mitigation of water related hazards, and water education and research in various aspect (Jayakumar et al., 2009). Between these method and initiatives is directing the research on the assessment of water balance to increase our thoughtful on the process and performance of hydrologic cycles for better sustainable management of water resources (Merka, 2000). A water balance assessment is estimated for each catchment and area to understand surface water and groundwater availability (fig.1). Water balance is a meaning that can be used in explaining the flow of water in and out of a system (Sutcliffe, 2004). For a closed system, the water balance equation uses the principle of conservation of mass whereby, precipitation entering the system is transferred into evaporation, transpiration, surface runoff and ground water recharge (Sharma et al., 2019).

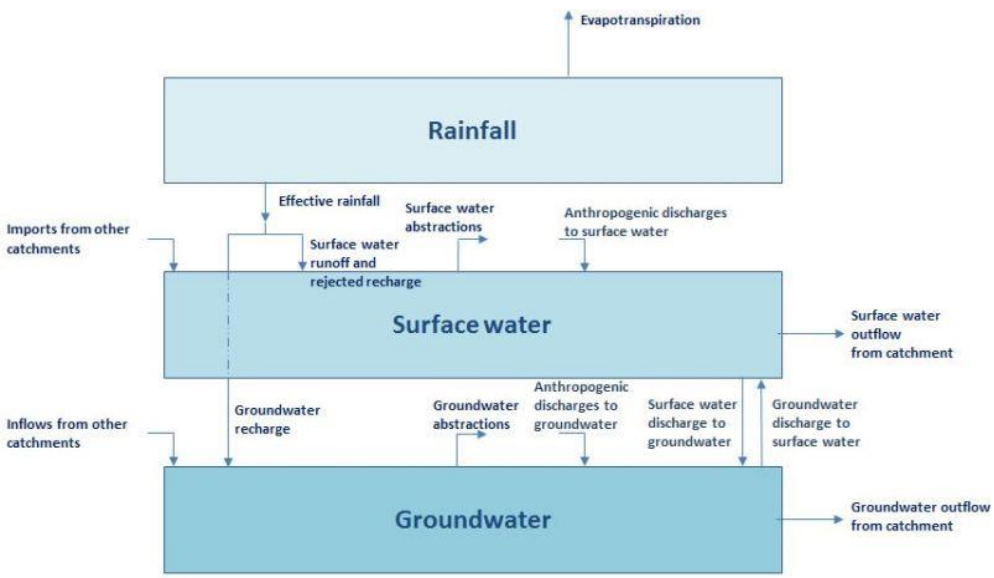

Fig. 1: Component of Water Balance Assessment (https://www.gsi.ie/en-ie/programmes-and-projects/groundwater/projects/gw3d/groundwater-resources-assessment/Pages/Water-balance.aspx)

Furthermore, having hydrological information/component of an area or catchment systems can be of abundant use in conflict management, planning water conservation, agricultural design, drainage and flood control. Hydrologic responses are dependent on judgements that are precise and estimates trustworthy in order to facilitate planning and managing water resources (Bao et al., 2012). Water balance study is becoming tremendously significant in facilitating water specialists and civil society to make knowledgeable decisions. The interrelated nature of water balance constituents has led to the need for information on the relationship between hydrological components and physical parameters. This helps in understanding the complexity of hydrologic processes being dealt with when carrying out any water resources related developments (Loucks and Van Beek., 2017), and therefore, assessment of water resources and water balance components is of significance for water resources management at global, continental and river catchment scales towards realizing sustainable use (Vorosmarty et al., 2015).

Afghanistan is placed between latitudes 29.5N-38.5N and longitudes 60.5E-75E with entire geographical area of 654,000 km^2. It is surrounded by Tajikistan, Uzbekistan, and Turkmenistan to the north, Iran to the west, Pakistan to the south and east and China. Considerable of the country is dominated by the Hindu Kush, the westernmost extension of the Karakorum and the Himalayas. Over three-quarters of the land are mountainous. The great mountain ranges of Pamir and Hindu Kush divide the country with high area of planes in the north, a mountainous central area, mountains and foot hills in the east and south east and lowland to the south and west (Ibrahimzada, 2012). For the water resources management purposes, the country is divided into five major river basins (Fig.2): Kabul River Basin, Northern River Basin, Helmand River Basin, Hari-Rod Murghab River Basin and Panj-Amu River Basin. In Afghanistan, surface water resources mainly originate from snow, rain and glacial melt. Natural storage of snow precipitation in the higher attitude of the Hindu Kush Mountains represents 80% of Afghanistan's water resources. The average annual volume of ground and surface water resources of the country is estimated around 69 BCM. Surface water resources accounts for 53 BCM of the total water resources potential and groundwater resources for the remaining 16 BCM in the country. In addition to its mountains, the country possesses many rivers, forests, lakes and desert areas. Only the Kabul River, joining the Indus river system in Pakistan, leads to the sea. Many rivers and streams simply empty into arid portions of the country, spending themselves through evaporation without replenishing the four major systems; others flow only seasonally. The study area is in northern part of Afghanistan. Several watersheds of the northern part of the country are classified as northern river basin. The watershed size of this basin is about 116,000 km^2. The run-off is discharged by Murghab, Kashan, Kushk and Gulran rivers out from the basin to Turkmenistan by Amu (Oxus) River. The other rivers, such as Samangan, Balkhab, Saripul and Shirin Tagab, however do not reach Amu River (DACAAR, 2007).

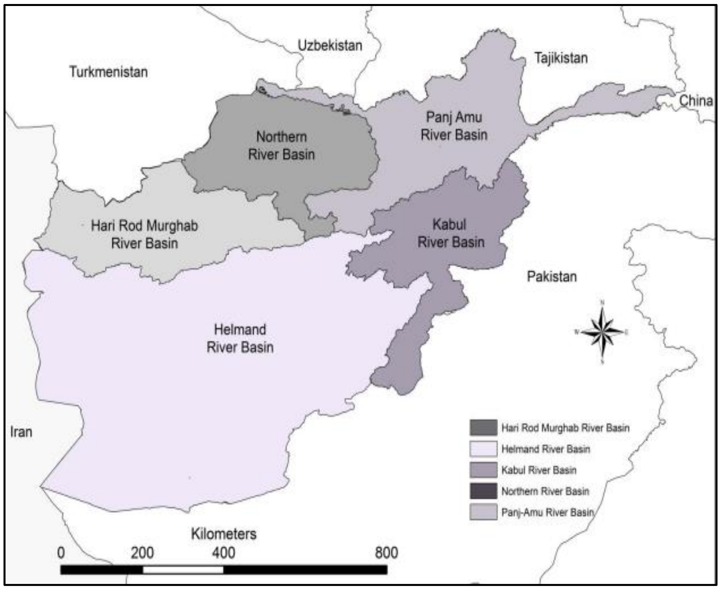

Fig.2: River Basin map of Afghanistan (Akhtar, 2017).

Data and Method

Surface water resources investigations in Afghanistan started in 1946. In 1964, the U.S. Agency for International development (USAID) with collaboration of Water and Soil Survey Authority of Afghanistan, developed a plan for a nationwide network of stream-gaging stations; subsequently, 149 stations were installed in five river basins of the country. Unfortunately, as a result of war hydrological network has been destroyed. In 2007, the rehabilitation of the country's hydro-meteorological network started and 183 hydro-meteorological station were installed. In present time, the hydrological data is being collected and is processed by NWARA. For the Hydrological of this study, data were collected from NWARA. For the Hydrological study, data were collected from Ministry of Energy and Water, USGS, free global digital data and others such as published reports. The available station data and its type is shown in the following table. The work flow of the assessment of water balance in the study area is shown in (fig.3). In this study the daily observed precipitation, air-temperature, relative humidity, with the discharge of hydro-meteorological stations was used from the national hydrometeorological network of observations stations of the MEW.

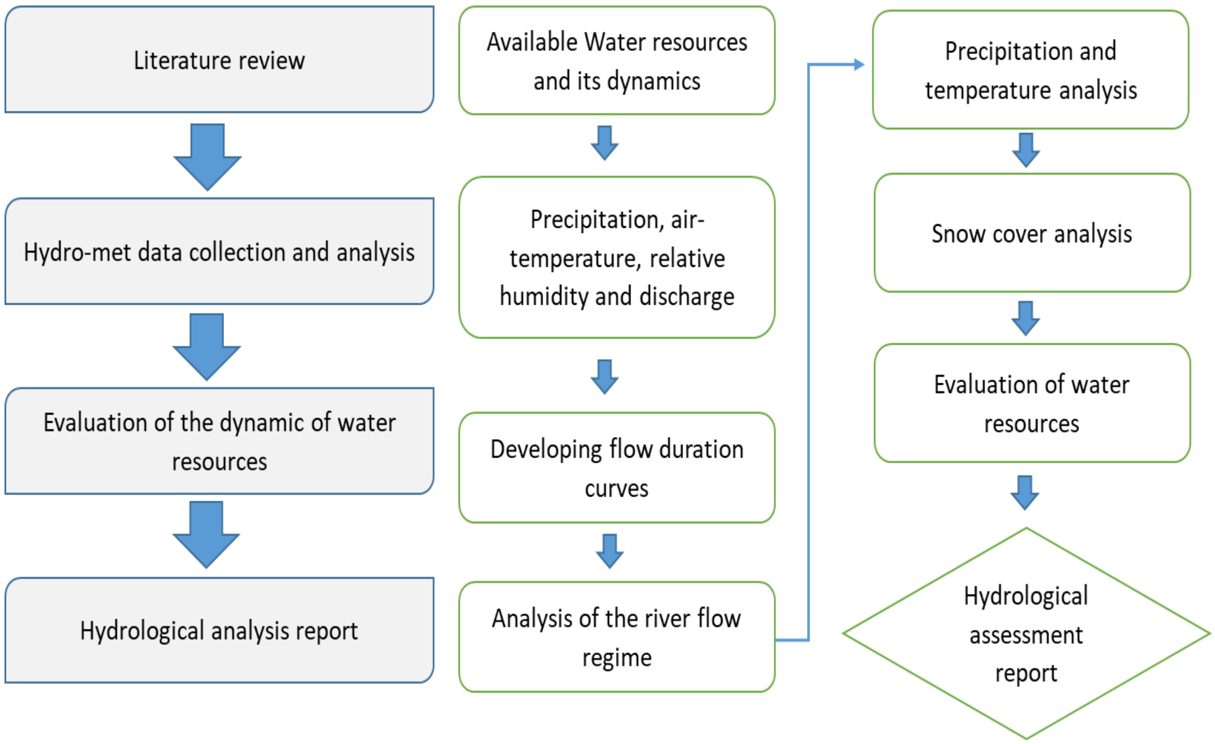

Fig.3: Flow chart of the study methodology

The meteorological data has been collected from Afghanistan Meteorological Departmen. They are collecting different meteorological parameters such as wind, rainfall, temperature, humidity etc. from a single station installed in a province. At present time, Ministry of energy and water has also installed a meteorological station nearby river each gauging station. They are also collecting meteorological data from 1963.

Open Source data

Climate –Raster maps

The digital open source global evaporative losses and rainfall data sets are available in URL https://earlywarning.usgs.gov/fews/search/Global. The climate change and historical climate (baseline) gridded data of 1^0 x 1^0 are available for Afghanistan. The gridded data are from World bank and available in URL http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_future_climate&ThisRegion=Asia&ThisCcode=AFG#ar5

The 40 plus threshold climate Change parameters are available freely which could be handy for agriculture. Four RCP scenarios from CMIP 5 with 22 models outputs are available for the analysis. The bias corrected CMIP 3 is also available in same URL

From 1950's to 1983, monthly rainfall data United Nation data bank. The data are province wise and can be freely downloaded from URL http://data.un.org/Data.aspx?d=CLINO&f=ElementCode%3A06.

The agro meteorological data are available from world Clim version 2. Data are freely available from 1970 to 2000 in URL http://worldclim.org/version2. The data is available from 10 m to 30 sec and available parameters are shown in table 1.2.

Table. 1: available gridded data

variable	10 minutes	5 minutes	2.5 minutes	30 seconds
minimum temperature (°C)	tmin 10m	tmin 5m	tmin 2.5m	tmin 30s
maximum temperature (°C)	tmax 10m	tmax 5m	tmax 2.5m	tmax 30s
average temperature (°C)	tavg 10m	tavg 5m	tavg 2.5m	tavg 30s
precipitation (mm)	prec 10m	prec 5m	prec 2.5m	prec 30s
solar radiation (kJ m^{-2} day^{-1})	srad 10m	srad 5m	srad 2.5m	srad 30s
wind speed (m s^{-1})	wind 10m	wind 5m	wind 2.5m	wind 30s
water vapor pressure (kPa)	vapr 10m	vapr 5m	vapr 2.5m	vapr 30s

Source: http://worldclim.org/version2

Study Area

The study area is located in Northern Afghanistan. It lies in three provinces, namely Kunduz, Balkh and Jawzjan, as shown below in (fig.4). The watersheds in this area are the Amu (Darya) River watershed, the Northern Rivers' watershed and the undrained zone.

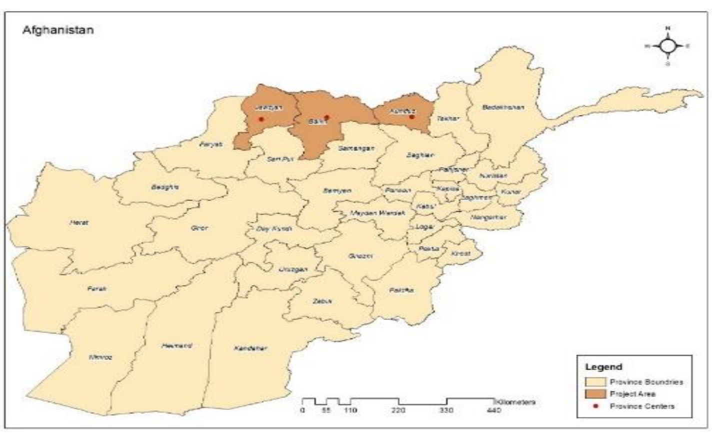

Fig.4: Study Area

Discussion:

Water Resources

Afghanistan, water in river is mainly due to rain, snow and glacier melt. Natural storage of snow precipitation represents 80% of Afghanistan's water. The amount of water received in snow accumulated areas is estimated to be around 150 Bm^3. The rest of the country receives 5 times less i.e.30Bm^3

annually through rainfall resulting in a total amount of 180 Bm3 for the whole country (FAO, 1996 cited AIMS/FAO 2004). The rivers can be divided as Amu Darya River Basins, Desert River Basins and Indus River Basins. The Amu Darya River Basin includes: 1-North eastern river basin, which contributes 48.12 Bm^3 of average water in a year, 2 -Northern River Basins which contributes 3.34 Bm^3 average water in a year and 3- Hari River (Hari Rud) Basin which contributes 1.6 Bm3 average water in a year. Likewise, Desert Basin is separated in 3 Basins, namely 1-South Western River Basins which contributes 1.73 Bm^3 average water in a year, 2 -Helmand River with 7.5 Bm3 average water in a year and 3 -Southern River Basins with 0.07 Bm^3 average water in a year. The Indus Basin is separated as 1 South Eastern River Basins which contributes 0.75 Bm^3 average water in a year and 2- Kabul River Basin 20.9 Bm^3 average water in a year. In total, around 84 Bm3 water available in average per annum in Afghanistan [IWMI 2002]. The river basin delineated by FAO/ AIIMS is presented in (fig.2). As mentioned above, around 84 Bm3 water average per annum is available in Afghanistan. The North Eastern River Basin (Amu Darya Basin) contributes 48.12 Bm3 per annum and Northern River Basin contributes 3.34 Bm3 per annum. In total, around 51.46 Bm3 of water per annum contributes to the gross 84 Bm^3, which is around 61.2 % contribution to total (table 2).

Table 2: Average Annual Flow of Afghanistan and Northern and North-eastern Basins (source: IWMI 2002)

Basins	Annual Average Flow (Bm^3/y)
North Eastern River Basin (Pyanj Basin)	48.12
Northern River Basin	3.34
Total Northern Basin and North Eastern Basin	51.46
All Basin Afghanistan	84
Total Northern Basin and North Eastern Basin's Contribution to Afghanistan	61.2%

The Amu Darya is one of the most important transboundary rivers in Central Asia and for North Afghanistan. It is a glacial river, silty and opaque, originating from the glaciers of the Pamir mountain range, and formed by the confluence of the Wakhan and Pamir rivers near the Chinese border. Also, it serves as most of the border between Afghanistan and Tajikistan and Uzbekistan before joining the Vakhsh River to become the Amu Darya. Bartang and Bakash rivers are the major tributaries from Tajikistan and Sukhandarya River is main tributary from Uzbekistan. The major contributing tributaries from Afghanistan is Wakhan Darya, Kokcha and Kunduz Rivers. The Amu River Basin, Pyanj River Basin (upper Amu), Major tributaries of Amu River in Afghanistan (Kokcha and Kunduz River) is shown in (Fig.5). As per the measured river flow data by MEW, the Upper Amu Darya (Pyanj) river's average annual flow at Sust Pyanj (headwater) is around 3.2 Bm3 per annum. At Sheghnan hydrometric station, the flow increases to average annual flow of 12.23 Bm3 per annum and at Khirmanjo hydrometric station in Tajikistan, it reaches average annual flow of 26 Bm3 per annum (Table.3). The Amu river flow recorded in Termiz hydrometric station in Uzbekistan is 65 Bm3 per annum.

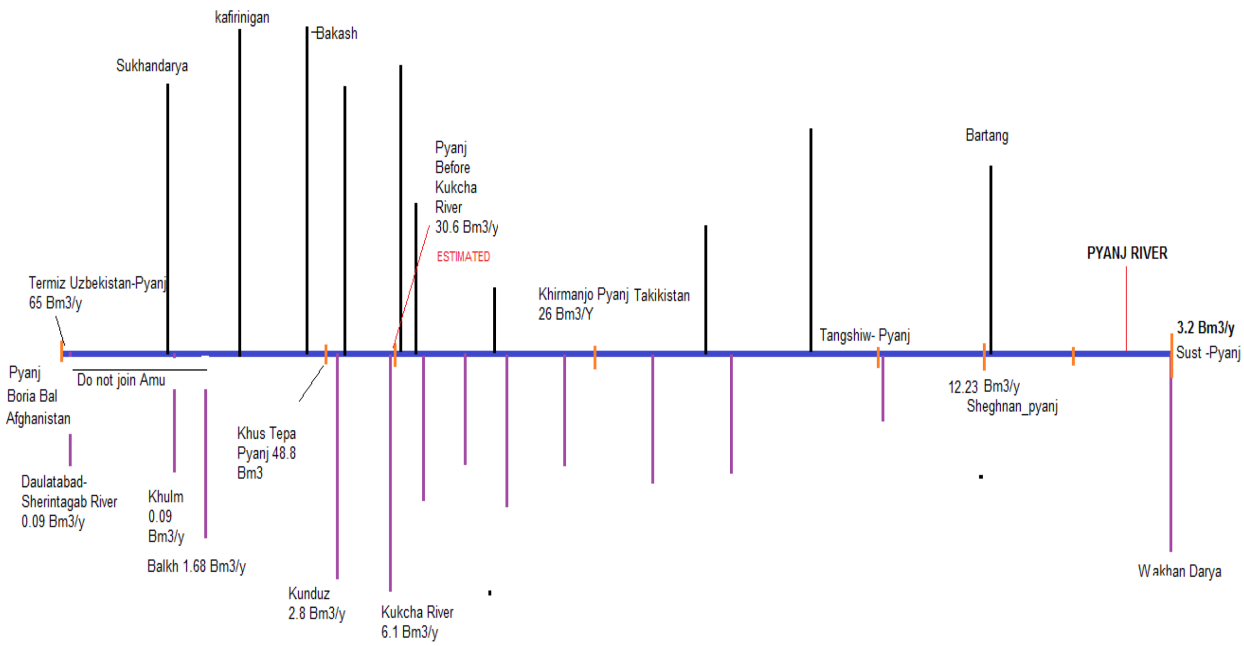

Fig. 5: Schematic Diagram of Flow in Panj River

Table. 3: Flow Assessment of Pyanj River

Station	River Name	Country	Annual Flow Bm^3	Catchment Area Km^2
Khirmanjo	Pyanj	Tajikistan	26	72356
Termez	Pyanj	Uzbekistan	65	213400
Sheghnan	Pyanj	Afghanistan	12.23	29945
Sust	Wakhan	Afghanistan	3.2	4636
Before Kokcha river *	Pyanj	Afghanistan	36.1	106790
Khush Tepa*	Pyanj	Afghanistan	48.8	154400
Klokh Tapa	Kunduz	Afghanistan	2.8	37100
Khwajghar	Kokcha	Afghanistan	6.1	20646

* Estimated

Climate

Most part of Afghanistan is dominated by subarctic mountain climate with dry and cold winters, except for the lowlands, which have arid and semiarid climates. In Afghanistan summers are hot and winters can be severely cold. Summer temperatures as high as 49 °C (120 °F) have been recorded in the northern valleys. However, the climate in the highlands varies with elevation, the Midwinter temperatures as low as -9 °C (15 °F) are common around the 2000 m elevation. Temperatures often range greatly within a single day. Variations in temperature during the day may range from freezing conditions at dawn to the upper 30 °C at noon. Most of the precipitation falls between the months of October and April. The deserts receive less than 100 mm of rain a year, whereas the mountains receive more than 1000 mm of precipitation, mostly as snow. The general climate of Afghanistan is a dry continental climate. There is a great variations in climate within Afghanistan due to presence of rugged topography. The average temperatures vary from minus 10 °C in winter to 34 °C in summer. About 50 percent of precipitation occurs in winter (January to March), much of which falls as snow in the central mountainous regions. Additional 30 percent precipitation falls in spring (April to June) and snowmelt runoff generally active in spring and summer months.

The study area lies within Kunduz, Balkh and Jawzjan Provinces of Afghanistan. The provinces has some variations in elevation and land use. Therefore, slight variations in climate could be expected. The climate in all 3 provinces is referred to as a local steppe climate. This climate is considered to be cold semi-arid climates (BSk) according to the Köppen-Geiger climate classification [www.climate-data.org].

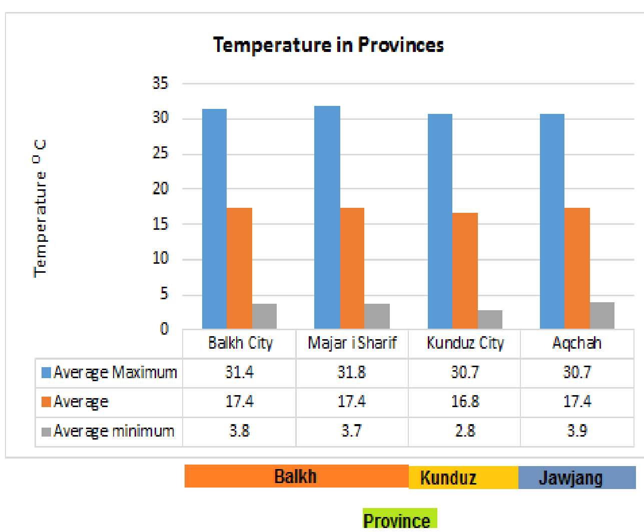

Fig. 6: Minimum, Maximum and Mean Temperature of the Three Provinces (cited www.climate-data.org)

Temperature

Balkh City is near to proposed study area and the average annual temperature is 17.4 °C. The temperature in July averages 31.4 °C and in January, the average temperature is 3.8 °C. The other close city in Balkh Province is Mazar-e-Sharif and it has also average annual temperature of 17.4 °C. July is the warmest month in Mazar-e-Sharif with an average of 31.8 °C and lowest average temperatures in the year occur in January, when it is around 3.7 °C.

In Kunduz Province, Kunduz City's average annual temperature is 16.8 °C. The temperatures are highest on average in July, at around 30.7 °C and at 2.8 °C on average, January is the coldest month of the year.

In Jawzjan Province, Aqchah City average annual temperature is 17.4 °C and July is the warmest month of the year. The temperature in July averages 30.7 °C. The lowest average temperatures in the year occur in January, when it is around 3.9 °C. The temperature patterns are shown in (fig. 6).

Humidity:

The humidity around the area is low during summer and high during summer. As per the Kunduz's (Kulokh Tapa) meteorological station data, the average maximum relative humidity is 85.9% in December and average minimum relative humidity is 5 % in December.

Rainfall

The rainfall is one of the direct water inputs for agriculture in Afghanistan. The Kunduz province receives nearly 242 mm in year is highest rainfall compared to others two provinces. The Balk province receives just 166 mm and Jawzjan province receives 229 mm of rainfall in a year (Table. 4). The monthly distribution of rainfall shows rainy season from November to May with high in February /March and remains dry during June to September. However, the amount of rain in Balkh is less than other two provinces, rainy season distribution is similar in all three provinces. The monthly rainfall distributions of three provinces is shown in (Fig. 7, 8 and 9). The average monthly rainfall over these provinces and the stations in the provinces is shown in (Table. 4).

Table. 4: Monthly Rainfall Distribution of Provinces and Available Meteorological Stations (Highlighted Columns) (Source: Afghanistan Meteorological Department, Ministry of Energy and Water, Afghanistan)

Month	Jawzjan	Kunduz	Balkh	Province	Station Name
	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)		
Jan	31.6	28.4	22.6	Balkh	Balkh
Feb	40.7	49.5	35.4	Balkh	Dawlat Abad
Mar	49.4	48.0	31.3	Balkh	Mazar
Apr	36.0	36.5	25.8	Balkh	Takhta Pul

May	13.6	18.5	8.6	Jawzjan	Aqchah
Jun	0.5	3.9	2.0	Jawzjan	Darzab
Jul	0.2	0.1	0.0	Jawzjan	Jawzjan
Aug	0.0	0.0	0.0	Kunduz	Aaqtepa
Sep	0.0	0.0	0.0	Kunduz	Ali Abad
Oct	5.1	3.1	3.1	Kunduz	Archi
Nov	37.4	22.3	23.5	Kunduz	Chahar Dara
Dec	14.6	31.9	13.8	Kunduz	Imam Sahib
Total Annual	**229.1**	**242.3**	**166.0**	Kunduz	Khan Abad
				Kunduz	Kunduz

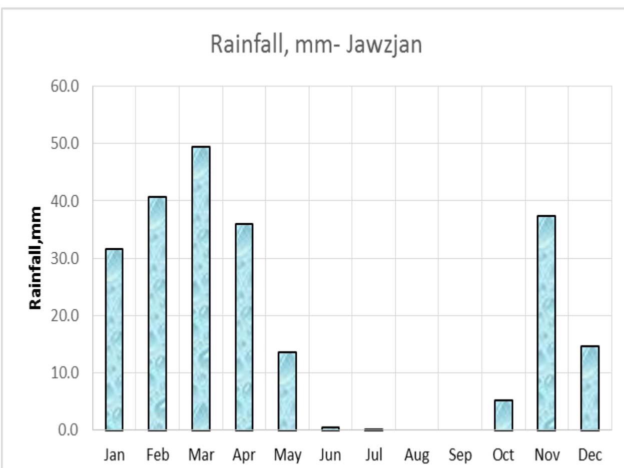

Fig. 7: Rainfall Distribution of Jawzjan Province

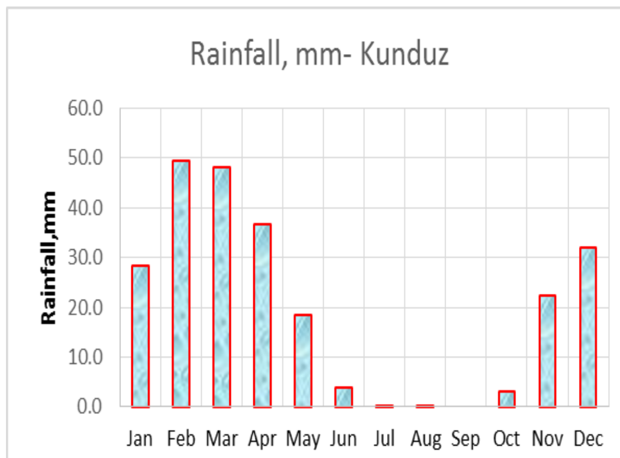

Fig.8: Rainfall Distribution of Kunduz Province

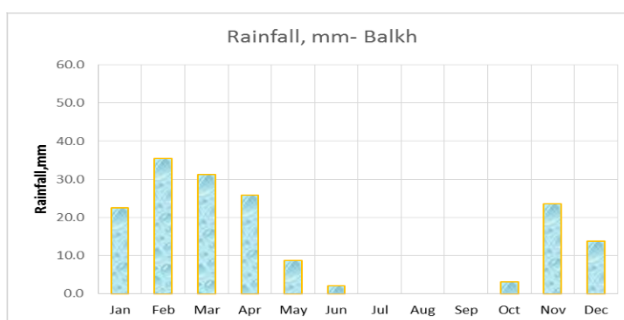

Fig.9: Rainfall Distribution of Balkh Province

Note: Few rain gauge stations are available in each Provinces, and out of these, Kunduz province has relatively dense network of rain gauge stations compare to other two provinces. The provincial monthly rainfalls was estimated by averaging rainfalls of the stations within the province. The data availability period for all stations is from 2011 to 2018.

potential river that can be utilize is Upper Amu River (Pyanj) and its Tributaries Kokcha and Kunduz River. The direct rain resources for this area is around 212 mm

(Average rain of three provinces, (Table.4). All potential rivers get water from both snow and rain.

Evapotranspiration:

The evapotranspiration at irrigated field near area is 1331 mm per annum [Modis digital Image]. As per the report of AIMS/FAO, 2004, the Kunduz city's total evapotranspiration is 1285 mm per annum with daily maximum 8.13 mm/day and minimum 0.43 mm/day and average daily 3.57 mm/day. In Mazar e Sharif, total evapotranspiration is 1376 mm per annum with daily maximum 8.47 mm/day and minimum 0.57 mm/day and average daily 3.82 mm/day.

Surface Water:

The study area is Kunduz, Balkh and Jawzjan Provinces and in present time, Khulm, Balkh, Kunduz and Sher e Pul Rivers are the major sources of water for irrigation in nearby areas. To irrigate the above rivers can contribute but not enough. The most potential river among 4 rivers is Kunduz which contributes 2.8 Bm^3 per annum.

The flow is studied from historical data collected by MEW for tributaries. The gauging stations considered for the study is shown in (Table. 5) and location is shown as circled in STAR sign in (fig. 10). The monthly contributions from these rivers in 3 provinces is shown in (Table. 6). The months May and June, river flows in high stage and dry month is September. The monthly flow hydrograph of rivers is shown in (Fig. 11).

Table. 5: Flow Assessment of Tributaries in Kunduz, Balkh, and Jawzjan Provinces (Source: Ministry of Energy and Water and USGS)

Station	**River Name**	**Province**	**Annual Flow Bm^3**	**Catchment Area Km^2**
Tang-i-Tashqurghan	Khulm	Balkh	0.09	8254
Kolokh Tepa	Kunduz	Kunduz	2.8	37100
Rabat-i-Bala	Balkh	Balkh	1.68	18035
Asiabad	Sar-e-Pul	Jawzjan	0.09	4256

Table. 6: Monthly Flow Assessment of Tributaries in Kunduz, Balkh, and Jawzjan Provinces (Source: Ministry of Energy and Water and USGS)

Province		**Kunduz**	**Balkh**	**Jawzjan**	**Balkh**	**Kunduz**	**Balkh**	**Jawzjan**	**Balkh**
Days in Month	**Month**	**Kunduz Flow in m3/s**	**Khulm Flow in m3/s**	**Sar-e-Pul Flow in m3/s**	**Balkh Flow in m3/s**	**Kunduz Flow Bm3/y**	**Khulm Flow Bm3/y**	**Sar-e-Pul Bm3/y**	**Balkh Bm3/y**
30	Jan	75.7	2.8	7.0	34.5	0.196	0.007	0.018	0.090
28	Feb	74.3	2.6	7.6	34.8	0.199	0.006	0.018	0.084
31	Mar	88.2	3.3	9.3	39.6	0.229	0.009	0.025	0.106
30	Apr	90.5	3.7	12.2	58.9	0.242	0.009	0.032	0.153
31	May	181.7	3.9	12.5	99.3	0.487	0.011	0.033	0.266
30	Jun	194.1	1.8	7.9	95.1	0.503	0.005	0.021	0.247
31	Jul	104.9	1.2	5.5	47.4	0.281	0.003	0.015	0.127
31	Aug	42.7	1.1	4.9	35.7	0.111	0.003	0.013	0.096
30	Sep	30.1	1.3	5.6	35.1	0.081	0.003	0.015	0.091
31	Oct	44.7	1.7	7.2	36.6	0.116	0.005	0.019	0.098
30	Nov	74.9	2.6	7.7	36.9	0.181	0.007	0.020	0.096
31	Dec	77.4	3.0	7.4	35.8	0.207	0.008	0.020	0.096
	Average	89.9	2.4	7.9	49.1	2.832	0.076	0.249	1.548

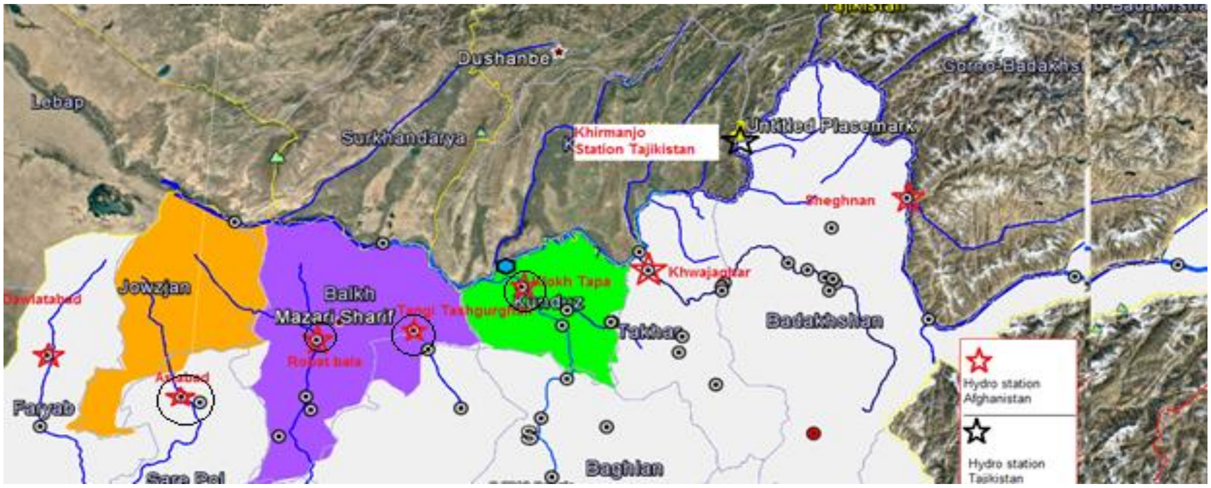

Fig. 10: Flow Assessment Locations

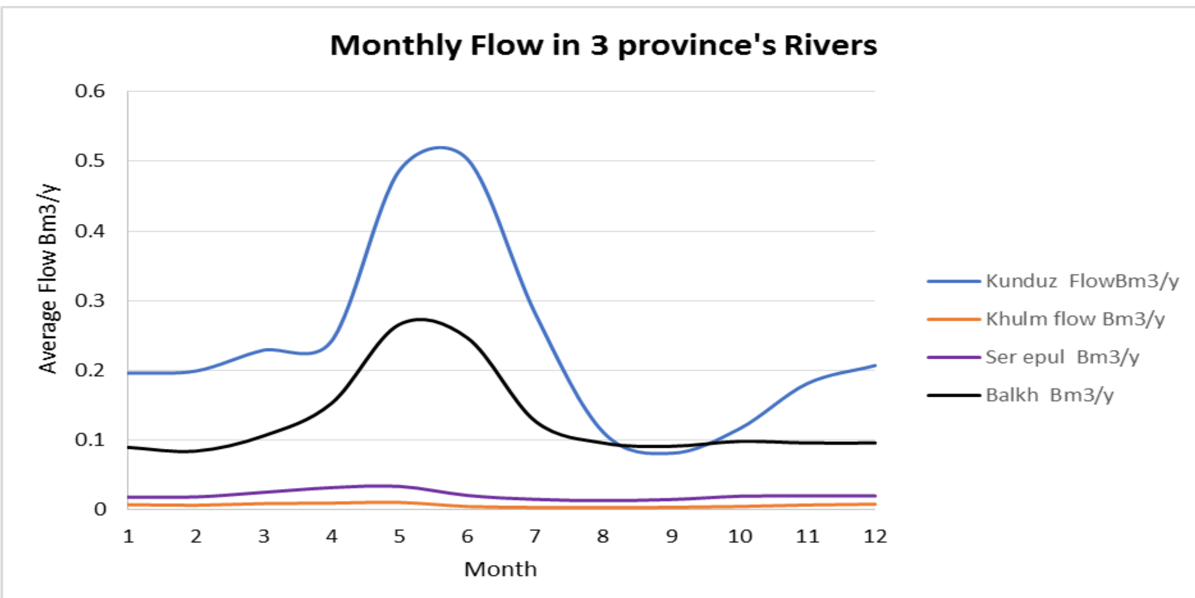

Fig. 11: Monthly Average Cumulative Flow

Note: The flow data is collected from USGS and Ministry of Energy and Water, and was used to assess water availability in these rivers. This data is from most downstream gauging stations of the river.

Domestic Water Demand

To estimate the household water demand, central statistics organization of Afghanistan report formed the base for estimation. According to the report, the total projected population for Kunduz, Jawzjan and Balkh provinces Population are 1049249, 559691 and 1382155 respectively. The settlement Distribution at the 3 provinces is shown in Figure 3.10 indicates its heavy concentration near river valley. Heavy settlements concentration is seen in Balkh and Kunduz provinces.

As per the WHO/SEARO Technical Note No. 9, a person needs 70 L/day (drinking, bathing and other use). Assuming 40% of province total population get benefits from canal, water requirement for human consumptions is estimated as 31 Mm3/year (2.6 Mm3/month) The water needed for each province is shown in Table. 7.

Table. 7: Water Requirements in Three Provinces

Province	Total Population	40% of Total Population	Water Needed at 70L/d	Water Needed Mm^3/y
Kunduz	1049249	419700	29378972	11
Jawzjan	559691	223876	15671348	6
Balkh	1382155	552862	38700340	14

FLOOD FREQUENCY

The Flood frequency analysis of Kunduz River is carried out using Gumble Method. The data is generated from 2008 to 2013 for gap period and series of 2008 to 2017 is used for analysis and the result is shown in Table. 8.

Table. 8: Flood Frequency of Kunduz River (Gumble Distribution)

Return Period (Year)	Flood M3/Sec
5	317
10	390
25	483
50	552
100	621
500	779
1000	847

Conclusion

Water is always a scarce resource that needs to be harnessed so as to meet the growing basic demand for development activities. It is serious to social and economic development and often directly affects the performances of the society. Its scarcity affects almost all social and economic developments and threatens the sustainability of human development activities and the whole ecosystem around.

The water cycle functions on a time and space scales. Since precipitation is the essential component of hydrological water balance, accurate and timely knowledge of catchment-scale precipitation is essential for improving the ability to manage freshwater resources and for expecting high-impact weather events. As a result, the future of water availability depends on the understanding of the spatial and temporal variation and interaction of hydrologic components hence, could be influential to assisting water planners in the formulation of strategies for water conservation. The calculation of water balance components is important for water resource assessment and management, particularly in water scarce area, when assessing the impact of climate change.

At country level surface water resources mainly originate from snow, rain and glacial melt. Natural storage of snow precipitation in the higher attitude of the Hindu Kush Mountains represents 80% of country water resources. Almost 70 percent of precipitation occurs in winter (Middle of December to Middle of March), much of which falls as snow in the central mountainous regions. Additional 30 percent precipitation falls in spring (Middle of March to Middle of June) and snowmelt runoff generally in spring and summer months. The monthly distribution of rainfall shows rainy season from November to May with high in February /March and remains dry during June to September. The study area receives an average annual precipitation of 212 mm, almost all of the precipitation occurs during the October to June period. The hydro-meteorological stations observed data shows relativity high temperatures during July, and low temperatures in winter during January.

Most part of Afghanistan is dominated by subarctic mountain climate with dry and cold winters, except for the lowlands, which have arid and semiarid climates. In Afghanistan summers are hot and winters can be severely cold. Summer temperatures as high as 49 °C (120 °F) have been recorded in the northern valleys. However, the climate in the highlands varies with elevation, the Midwinter temperatures as low as -9 °C (15 °F) are common around the 2000 m elevation.

In Balkh City the average annual temperature is 17.4 °C. The temperature in July averages 31.4 °C and in January, the average temperature is 3.8 °C and in Mazar-e-Sharif average annual temperature of 17.4 °C. July is the warmest month in Mazar-e-Sharif with an average of 31.8 °C and lowest average temperatures in the year occur in January, when it is around 3.7 °C. In Kunduz Province, Kunduz City's average annual temperature is 16.8 °C. The temperatures are highest on average in July, at around 30.7 °C and at 2.8 °C on average, January is the coldest month of the year. In Jawzjan Province, average annual temperature is 17.4 °C and July is the warmest month of the year. The temperature in July averages 30.7 °C. The lowest average temperatures in the year occur in January, when it is around 3.9 °C.

The rainfall is one of the direct water inputs for agriculture in Afghanistan. The Kunduz province receives nearly 242 mm in year is highest rainfall compared to others two provinces. The Balk province receives just 166 mm and Jawzjan province receives 229 mm of rainfall in a year. The amount of rain in Balkh is less than other two provinces, rainy season distribution is similar in all three provinces. The direct rain resources for this area is around 212 mm (Average rain of three provinces). All potential rivers get water from both snow and rain.

The evapotranspiration is 1331 mm per annum. Kunduz city's total evapotranspiration is 1285 mm per annum with daily maximum 8.13 mm/day and minimum 0.43 mm/day and average daily 3.57 mm/day. In Mazar e Sharif, total evapotranspiration is 1376 mm per annum with daily maximum 8.47 mm/day and minimum 0.57 mm/day and average daily 3.82 mm/day.

Khulm, Balkh, Kunduz and Sher e Pul Rivers are the major sources of water for irrigation in nearby areas. To irrigate the above rivers can contribute but not enough. The most potential river among 4 rivers is Kunduz which contributes 2.8 Bm^3 per annum. The months May and June, river flows in high stage and dry month is September.

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