Publisher homepage: www.universepg.com, ISSN: 2663-7804 (Online) & 2663-7790 (Print)

https://doi.org/10.34104/ajeit.021.090094

Australian Journal of Engineering and Innovative Technology

Journal homepage: www.universepg.com/journal/ajeit


# Assessment of the Irrigation Water Supply and Demand in Eastern Afghanistan: A Case Study of Behsud Canal in Nangarhar Province

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## ABSTRACT

The study was carried out in one of the districts of Nangarhar province located in Eastern Afghanistan between latitude 34.25° N and longitude 70.50° E. Nangarhar has huge ground and surface water resources. There are 78 irrigation canals in the province having an overall length of 365 km. Behsud Canal is located in Behsud district of Nangarhar province of Afghanistan. The results showed that highest crop water requirements were found for the month of July in Behsud Canal. Similarly, water application efficiency ranged recorded from 34% to 65.2%. Average evapotranspiration was found to be 49% in present canal. The irrigation water demand increased with the increased size of the agriculture field for the production of crops in Behsud Canal of Nangarhar province.

**Keywords**: Water supply, Water demand, Canal, Agriculture land, Nangarhar, and Afghanistan.

## INTRODUCTION:

Irrigated agriculture is considered as a backbone and mainstay for food security and income for majority of the rural population in Afghanistan. Its contribution is for more than half of the country's GDP, 70% of the total crop production, and provides a reliable and sustainable production base for many rural communities (Roche *et al.,* 2021).

The total cultivable area of Afghanistan is about 8 million hectares, which is 12% of the total area (Alan *et al.,* 2012).Approximately3.9millionhect-aresof Afghanistan land is cultivated, and out of the total 1.3 mill-ion hectares is rain-fed while the rem-aining 2.6 million hectares is irrigated (Mashal, 2018). This irrigated area produces almost 85% of all agricultural productions in Afghanistan (Rout, 2008). Basin and border irrigation for grains and furrow irrigation for vegetables and grapes are the two most common irrigation techniques used in both traditional and modern irrigation schemes (Qureshi, 2002). Farmers frequently misunderstand the water needs of crops, and over-irrigating fields is a wide-spread practice (Gupta and Seth, 2009). Both ancient and modern irrigation systems have an overall efficiency of approximately 25 to 30%, which leads to water loss and low yield (Wegerich, K, 2010).

Soil water balance model were applied to calculate the depth of irrigation needed to refill the soil profile (Ali*et al.,* 2012). These are the net irrigation requirements (NIR) (Smith M, 2000). To determine the gross irrigation requirements and management permitted deficiency, NIR were divided by an application efficiency that accounted for deep percolation losses caused by irrigation in consistency. Hussain *et al.* (2007) examined the water potential of two irrigated systems: Chishtian in Pakistan's Indus basin and Bhakra in India's Ganges basin.

They demonstrated that yields differ significantly, and as a result, WP using the Indian approach reports greater numbers (Hashimi *et al.,* 2018). They claimed that increased land productivity and insufficient irrigation were to blame for the Indian system's superior productivity (Pardeep, 2014).This research study also encompassed water application efficacy and water output in the service area of Behsud Canal in eastern province of Nangarhar, Afghanistan with the following objective to regulate the cropping patterns in service area of this canal.

## MATERIALS AND METHODS:

### Study area

The current study was conducted in Behsud district of Nangarhar province located in eastern Afghanistan between latitude 34.45° N and 70.65°E (**Fig.1**). The elevation above mean sea level ranges from 580 to 700 m. Soil texture is sandy and silt loam. Nangarhar province has abundant resources of both surface and ground water. There are 78 irrigation canals in the Nangarhar province having an overall length of 365 km (Ghaforzai *et al.,* 2021).

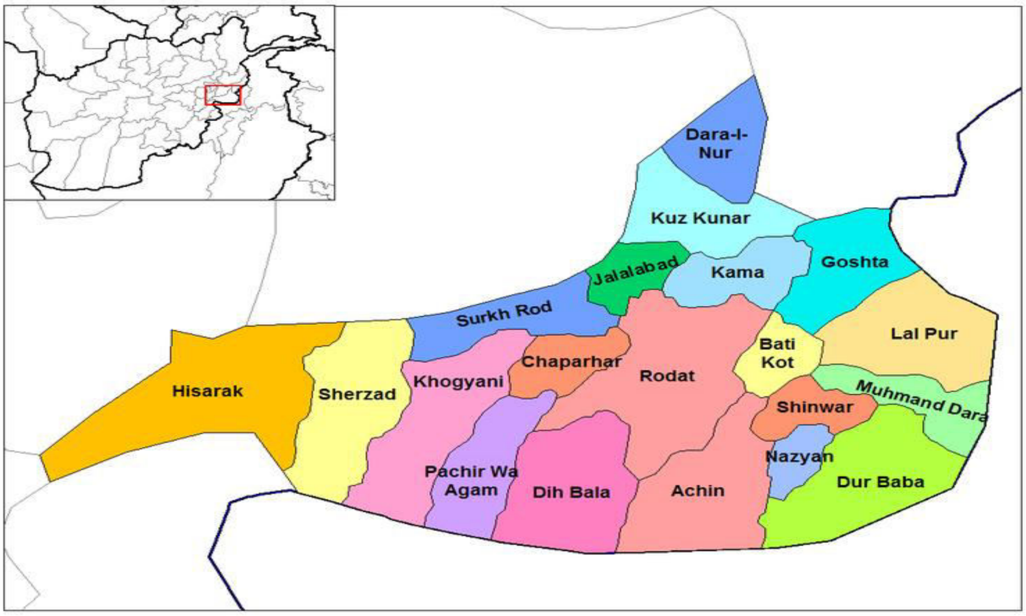


**Fig. 1:** Map of Nangarhar province showing study area.

### Assessment of water supply and demand

### Discharge measurement

Discharges were measured at head, middle and tail reaches of the Behsud canal. A digital Current meter "Flow Tracker Handheld ADV" by "SonTek" was applied for discharge measurement at head; middle and tail reaches of the Behsud canal. At first, the width of water surfaces was measured through tape and then it was divided into a number of sections. At each section the depth of irrigation water was calculated. Based on water depth two to three readings were recorded. If the depth was greater than 46 cm then two readings were recorded at 0.2 and 08 of depth. Only one measurement was taken at 0.6 when the depth was less than 46 cm (Bagchi *et al*., 2020).

### Daily monitoring of water level in the canal

For the development stage discharge relationship, white marks and measuring gauges were established at head, middle and tail reaches of each canal. Daily gauge and white mark readings were recorded.

### Stage discharge relationship

Stage discharge relationships were developed for each section of the canal. Data was measured from the white marks.

### Irrigation water demand

Irrigation water demands were measured by using an updated FAO developed software Cropwat 8.0 version. The Cropwat 8.0 uses Penman-Monteith method for calculating reference crop evapotranspirtion. These projections are applied to irrigation demand and crop water needs. All the meteorological data needed for CROPWAT were obtained from Jalalabad meteorological station located at 20Km aerial distance from study area during the period (April, 2016 to November, 2017).

### Reference crop evapotranspiration ($ET_0$)

Reference crop evapotranspiration is the sum of evaporated water from a reference crop like grass (15 cm) having optimum soil and water condition and were calculated through Cropwat (8.0).

**Crop co-efficient ($K_c$)**

$K_c$ values always remain constant for various crops but it continuously changes with different growth stages of the crop. $K_c$ values in this research study were obtained from FAO manual 33. $K_c$ values for crops grown in the Behsud canal are given in **Table 1**.

**Table 1:** Crop coefficient values of Behsud Canal in Nangarhar province.

| Crop | Initial | Developing | Developing | Mid | Late |
|---|---|---|---|---|---|
| Rice | 1.1 | 1.13 | 1.15 | 1.11 | 1.06 |
| Maize | 0.51 | 0.84 | 1.13 | 1.14 | 1.11 |
| Sugarcane | 0.47 | 0.53 | 0.92 | 1.16 | 1.17 |
| Cotton | 0.35 | 0.52 | 1.01 | 1.18 | 1.14 |
| Vegetables | 0.7 | 0.9 | 1 | 0.96 | 0.94 |

**Crop water requirements ($ET_c$)**

The crop evapotranspiration ($ET_c$) differs distinctly from the reference evapotranspiration as the ground cover, canopy properties and aerodynamic resistance of crop are different from grass. The crop coefficient incorporates the influence of traits that separate field crops from grass. The crop coefficient approach multiplies the crop evapotranspiration by $ET_0$ with $k_c$ crop.

## RESULTS AND DISCUSSION:

**Crops demand**

Crops demand was estimated from reference crop evapotranspiration ($ET_o$), crop water requirements ($ET_c$), and irrigation water allowance. Different steps were applied to estimate the crop water requirements are given as follows:

**Potential evapotranspiration ($ET_o$)**

The rate of potential evapotranspiration increased from month of January to August for canal command area. Onward to August ETo decreased till December. Highest ETo was recorded in month of June and July as given in the **Fig. 2**.

**Crop water requirements ($ET_C$)**

**Table 2** lists the daily crop water requirements of the primary crops growing in the Behsud Canal service area.

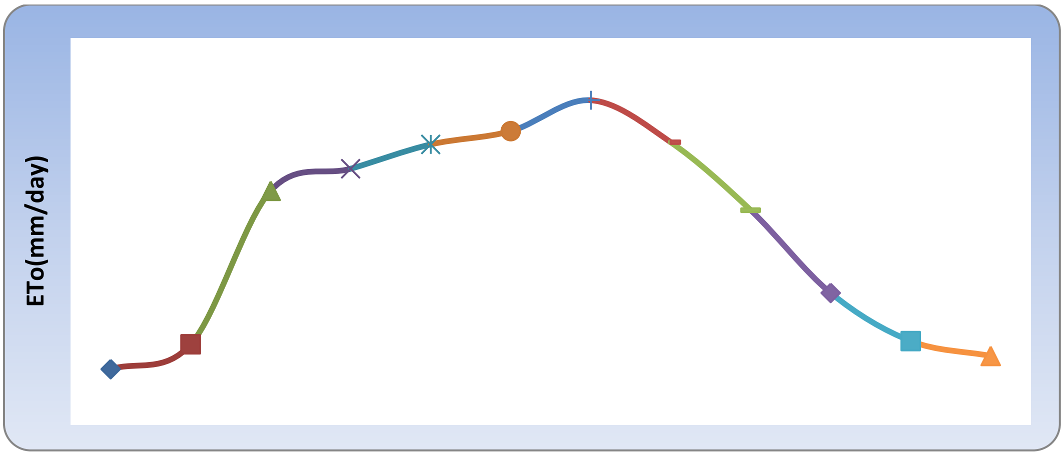


**Fig.2:** Potential Evapotranspiration ($ET_o$) of the study area.

**Table 2:** Crop water requirements of Behsud Canal.

| Month | May | | | June | | | July | | | August | | | September |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Decade | | | | | | | | | | | | |
| Crop | I | II | III | I | II | III | I | II | III | I | II | III | I |
| | (mm/day) | | | | | | | | | | | | |
| Rice | 3.3 | 5.5 | 5.7 | 5.8 | 5.9 | 6.3 | 6.7 | 6.6 | 6.3 | 6.1 | 5.6 | 5.0 | 4.5 |
| Maize | 2.3 | 2.5 | 2.7 | 3.5 | 4.4 | 5.5 | 6.5 | 6.8 | 6.4 | 6.1 | 5.7 | 5.2 | 4.7 |
| Sugarcane | 2.9 | 2.0 | 2.0 | 2.2 | 2.8 | 3.6 | 4.5 | 5.5 | 6.0 | 6.2 | 6.0 | 5.5 | 5.0 |
| Okra | 3.2 | 3.6 | 3.7 | 4.2 | 4.8 | 5.5 | 5.8 | 6.0 | 5.7 | 5.1 | | | |
| Tomato | 2.8 | 3.1 | 3.1 | 3.2 | 3.9 | 4.8 | 5.8 | 6.7 | 6.4 | 6.1 | 5.8 | 5.3 | 4.4 |

**Crops irrigation demand**

For the finding of irrigation demand overall efficiency was fitted in Cropwati. E overall system efficiency for Behsud Canal 38%. Demand for crops grown at Behsud Canal is presented as below.

**Table 3:** Crops irrigation demand of BehsudCanal service area.

| **Month** | **May** | | | **June** | | | **July** | | | **August** | | | **September** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Decade** | | | **Decade** | | | **Decade** | | | **Decade** | | | **Decade** | | |
| | I | II | III | I | II | III | I | II | III | I | II | III | I | II | III |
| Crop | Water Demand (l/s/ha) | | | | | | | | | | | | | | |
| Rice | 0.3 | 0.6 | 0.6 | 0.6 | 0.6 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.6 | 0.5 | 0.5 | 0.4 | |
| Maize | 0.5 | 0.6 | 0.8 | 1.1 | 1.5 | 1.6 | 1.7 | 1.8 | 1.8 | 1.7 | | | | | |
| Sugarcane | 0.5 | 0.3 | 0.4 | 0.5 | 0.7 | 1.0 | 1.2 | 1.5 | 1.7 | 1.9 | 1.8 | 1.7 | 1.6 | 1.5 | 1.3 |
| Okra | 0.7 | 0.8 | 1.0 | 1.2 | 1.4 | 1.4 | 1.4 | 1.5 | | | | | | | |
| Tomato | 0.6 | 0.6 | 0.7 | 1.0 | 1.3 | 1.5 | 1.6 | 1.7 | 1.7 | 1.6 | 1.4 | 1.1 | | | |

**Crops demand and irrigation supply comparison**

As given in **Fig. 3** at Behsud Canal demand exceeded supply in month of May, July and August. According to socio economic survey farmers also mentioned that they had limited water supply in these months at middle and tail reaches. As Canal is a government managed canal so there is no greater variation in supply (discharges) throughout the growing season except in first decade of September supply was zero. Possible reason for which is lack of flow regulators at its off take from Kabul River. Demand supply comparisons for both canals are presented as below.

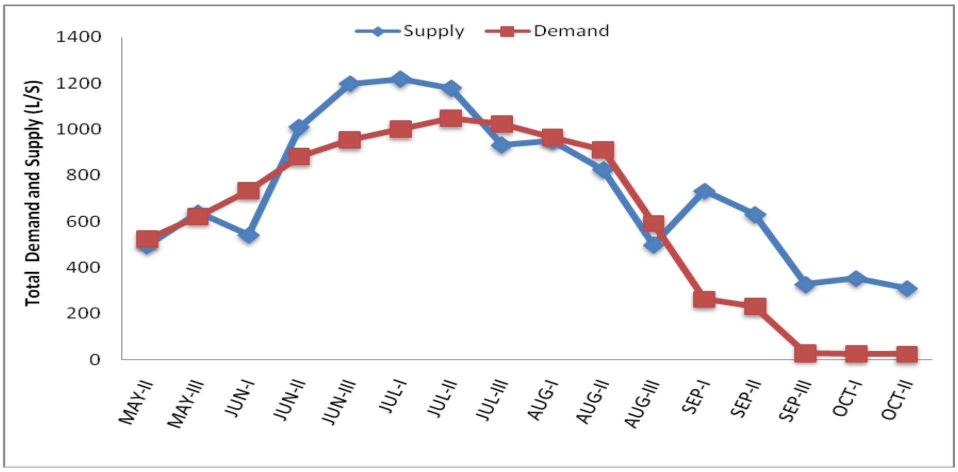


**Fig. 3:** Irrigation supply and demand comparison in service area of Behsud canal.

## CONCLUSION:

Rice was the most dominant crop grown at the head reaches of study area, followed by maize. The highest crop water requirements were found for the month of July in Behsud canal. The application efficiency ranged from 34%to 66.17% and average evapotranspiration was reported to be 49%.The depth of irrigation water applied to major crops at Behsud Canal ranged from 31.2 to 62.3mm.Application efficiency increased with decreased in field size at the study canal.

## ACKNOWLEDGEMENT:

The authors received no financial support for this research, authorship or publication of this article.

## CONFLICTS OF INTEREST:

The authors declare no conflict of interest.

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**Citation:** Ghaforzai A, Stanikzai MZ, Dost R, Agha N, Rahmati J, Ullah S, Diwaagali AA, and Baha N. (2022). Assessment of the irrigation water supply and demand in Eastern Afghanistan: a case study of Behsud canal in Nangarhar province. *Aust. J. Eng. Innov. Technol.*, **4**(5), 90-94.
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