**The Lighthouse Journal of Social Sciences, Vol. 04, Issue 2, Winter 2025, pp. 01-10**

# Economic Impact of Irrigation Development in the Command Areas of Gomal Zam Dam Project, Dera Ismail Khan and Tank Districts of Khyber Pakhtunkhwa: A Case Study of Wheat Crop

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## ABSTRACT

*Having enough irrigation water is important for increasing crop production and improving the livelihoods of rural communities. This study focuses on the impact of the Gomal Zam Dam (GZD) Project on wheat production and its income per acre in Dera Ismail Khan and Tank Districts of Khyber Pakhtunkhwa. The baseline information (wheat production and income per acre before project/intervention) and post-information (wheat and income per acre after project/intervention) were considered in the study to achieve the research goal. The statistical package SPSS was used to apply the paired t-test in the study. The results revealed that the GZD Project has a significant role in increasing wheat production per acre, $M_{before}$ = 401.40 kg/acre, $M_{After}$ = 1258.3 kg/acre, t (46) = -31.33, and p < 0.05, as well as net income per acre in the common areas, $M_{before}$ = 17875.83 Rs/acre, $M_{After}$ = 46304.69 Rs/acre, t (46) = -18.26, and p < 0.05. It can be concluded that the GZD Project has significantly increased wheat production and net income. These results imply that irrigation development can play a vital role in enhancing agricultural productivity and supporting rural livelihoods in the command area.*

**Keywords:** *Gomal Zam Dam, Dera Ismail Khan, Tank districts, Wheat Production, Income*

## INTRODUCTION

Irrigation, which provides water to the land, plays a significant role in the agricultural sector and on which agricultural crops heavily depend. All over the world, 20% of lands receive irrigated water and produce 40% of food worldwide (FAO, 2015). In Asia, 41% of the total cultivated land is irrigated, which significantly contributes to the Green Revolution when combined with improved mechanization and inputs (Hazell, 2009).

In Pakistan, the per capita availability of water is below 1000 $m^3$, indicating a water-stressed nation (Rizwan et al., 2018). Due to the higher growth rate, Pakistan is facing serious water supply problems. Furthermore, the increase in population demands higher food availability,

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Manuscript Submitted: December 12, 2025
Manuscript Accepted: December 23, 2025

which can be achieved through sufficient water availability for agricultural land. It has been predicted that the requirements for future food production can be fulfilled if water diversion for irrigation is increased by up to 17% and food production from irrigated lands is increased by up to 40% (Bos et al., 2005). The management of irrigation water suffers from many serious problems. The majority of farmers use flood irrigation, which wastes applied irrigation water by up to 50-60% (Qureshi & Hanjra, 2010; Ambast et al., 2006).

In Pakistan, 54.7 million acres of land are cultivated, of which 76.71% (42 million acres) is irrigated and 23.28% (12.7 million acres) depends on rainfall (Nasir et al., 2021). In Khyber Pakhtunkhwa, 28.86% (4 million acres out of 41.1 million acres) of the total area is cultivated, of which 2.1 million acres is irrigated, and the remaining 1.9 million acres depends on rainfall irrigation, meaning the area has no availability of water for crops (GoPK, 2016). In the rain-fed areas of Khyber Pakhtunkhwa, farmers use minimal inputs due to the higher risk of crop failure, which consequently leads to widespread food insecurity (Ashraf et al., 2007). Constructing water dams in such areas could help utilize uncultivated areas for crop yields (Khan and Shah, 2012).

The southern districts of Khyber Pakhtunkhwa [Dera Ismail Khan (DI), Tank, etc.] are very capable of producing agricultural crops. However, due to the lack of irrigation water in mentioned regions, production is negligible (Khan et al., 2017). The Government of Khyber Pakhtunkhwa with the assistance of USAID and WAPDA, has constructed the Gomal Zam Dam (GZD) project in the command areas of the DI Khan and Tank districts. In the GZD command area, the popular irrigation source is spate irrigation, locally known as Rod Kohi (Asif et al., 2016). The major crops of the command area are wheat and gram (Khan et al., 2017).




*Figure-1: Command Area of GZD*

Furthermore, the GZD project has a generation capacity of 17.4 MW and a live storage capacity of 0.892 MAF of water. There are two canals fed from the 35 km downstream reservoir at Dera Ismail Khan: one canal, named the Main Canal, leads toward Kulachi and Dera Ismail Khan, and the other, the Waran Canal, leads to District Tank. The total command area in both districts is 196,000 acres, and with the addition of this land, the loss of agricultural land in other districts will be minimized. The addition of this large chunk of land could position the districts of Dera Ismail Khan and Tank as the food basket of Khyber Pakhtunkhwa.




Figure-2**:** *View of GZD*

## LITERATURE REVIEW

In the past, many studies addressed that irrigation development projects had a positive effect on agricultural productivity, farm income, and overall rural development. Access to reliable irrigation water helps farmers boost crop yields, cultivate more land, and minimize the risks associated with unpredictable rainfall (Edwards & Smith, 2018). Previous research indicates that irrigated farms generally achieve higher cropping intensity and greater income than non-irrigated farms, particularly when irrigation water is reliable and well-managed (Jin et al., 2012). Research focusing on wheat production reveal that proper irrigation timing and depth significantly improve grain yield and water productivity, even under limited water availability (Getachew et al., 2025), and that applying irrigation at critical growth stages can lead to meaningful gains in yield and farm profitability (Ren et al., 2025). Other evidence suggests that improved irrigation methods result in better economic returns by saving water and increasing productivity compared to conventional practices (Bakhsh et al., 2015). Research on irrigation development further shows that the availability of canal water encourages crop diversification, increases cultivated area, and improves

household welfare when supported by appropriate agronomic practices (Khan et al., 2018). Additionally, research shows GZD in Pakistan affects local temperature, humidity, and rainfall, with differences observed across regions and over time (Afzal et al., 2022).

Despite these findings, limited attention has been given to district-level command areas and to comparing agricultural outcomes before and after irrigation development. This study addresses this gap by examining pre- and post-irrigation changes in wheat productivity and farm income in the command areas of the GZD Project in Dera Ismail Khan and Tank districts, including land that was previously barren. It further expects that the findings will indicate that similar irrigation interventions in the command areas of other dam projects implemented by the irrigation department could promote wider agricultural development in the province and contribute to achieving the objectives of the provincial government's Food Security Policy (2021).

## RESEARCH METHODOLOGY

### Field Experimentation and Crop Management

The wheat crop variety Faisalabad 2008 was cultivated by 47 farmers in the study area, with each farmer sowing the crop on one acre of land. Sowing was carried out on different dates according to farmers' field conditions and water availability. Standard fertilizer practices were followed during crop production. Urea and DAP (Diammonium Phosphate) were used as the main fertilizers, with one bag of urea and one bag of DAP applied at the time of sowing to support early crop growth and establishment. A second dose of urea was applied at the time of the first irrigation to promote vegetative growth. Throughout the growing season, a total of four irrigations were applied to the crop to ensure adequate moisture at critical growth stages. In addition, fungicides were used to control the incidence of crop diseases, while weedicides were applied to reduce weed infestation and minimize competition for nutrients, water, and sunlight. Furthermore, data on wheat yield and its income were collected for both the pre-intervention and post-intervention phase. The wheat yields and income before the intervention were compared with those after the intervention to assess the impact of improved irrigation and crop management practices on wheat productivity.

### Statistical Analysis and Analytical Framework

The collected data were analyzed using a paired t-test to examine the impact of irrigation development on wheat production and its income. The paired t-test was applied to compare the differences in mean wheat yield (kg per acre) and income (Rs per acre) between the pre-intervention and post-intervention periods following the initiation of the GZD Project. The hypotheses were formulated in terms of the mean paired difference ( $\mu_d$ ) between pre- and post-intervention outcomes. The null hypothesis states that there is no significant difference in wheat yield (and net income) before and after the initiation of the GZD Project ( $H_0 : \mu_d = 0$ ), while the alternative hypothesis assumes a significant difference between pre- and post-intervention outcomes ( $H_A : \mu_d \neq 0$ ). Statistical significance was tested at a probability level of $p \leq 0.05$. Additionally, the software SPSS version 25 was used to obtain the desired analysis.

Furthermore, the paired t-test was calculated using the formula:

$$t = \frac{\bar{d}}{\frac{s_d}{\sqrt{n}}}$$

Where,

$\bar{d}$ represents the average paired difference of wheat yield (kg/acre) before and after initiation of GZD in command area development project (GZD-CADP), Dera Ismail Khan and Tank Districts, $s_d$ denotes the standard deviation (variability) paired difference of wheat yield (kg/acre) before and after initiation of GZD in command area development project (GZD-CADP), Dera Ismail Khan and Tank Districts and *n* is the total number of beneficiary (farmers). The same analysis was run for wheat yield net income (Rs/acre).

## RESULTS & DISCUSSION

This section presents the results of the study, including the demographic characteristics of the farmers and the impact of the GZD Project on wheat yield and its net income. Table 1 summarizes the key demographic features of the participating farmers. The results showed that the majority of farmers (51.1%) were illiterate. Regarding tenancy status, most farmers (91.5%) owned their land, while 8.5% were tenants. On average, the farmers had 22.02 years (*SD* = 12.64) of farming experience. The average number of small and large animals per farm was 6.09 (*SD* = 7.23) and 3.38 (*SD* = 2.22), respectively.

**Table 1**

Farmers Demographic Characteristics

| *Characteristic* | | *N* | *%* | *M* | *SD* |
|---|---|---|---|---|---|
| Education | Illiterate | 24 | 51.1 | | |
| | Middle | 1 | 2.1 | | |
| | Matric | 10 | 21.3 | | |
| | F.A | 4 | 8.5 | | |
| | B.A | 3 | 6.4 | | |
| | M.A | 5 | 10.6 | | |
| Tenant Status | Owner | 43 | 91.5 | | |
| | Tenant | 4 | 8.5 | | |
| Farming Experience | | | | 22.02 | 12.64 |

| | | |
|---|---|---|
| Number of Small Animals | 6.09 | 7.23 |
| Number of Large Animals | 3.38 | 2.22 |

A paired t-test was applied to examine whether or not wheat yield (kg/acre) significantly differs before and after the initiation of GZD-CADP in Dera Ismail Khan and Tank Districts. The results showed that the average wheat yield after initiating GZD-CADP is higher than the average wheat yield before GZD-CADP. The results of the paired t-test showed that the average wheat yield significantly increased after initiating GZD-CADP in Dera Ismail Khan and Tank Districts compared to before initiating the proposed intervention in the command area, $M_{\text{before GZD-CADP}}$ = 401.40 kg/acre ($SD_{\text{before GZD-CADP}}$ = 21.29), $M_{\text{After GZD-CADP}}$ = 1258.3 kg/acre ($SD_{\text{After GZD-CADP}}$ = 183.18), $t(46)$ = -31.33, and $p < 0.05$ (Table 2). These results are also illustrated in Figure 3 by clearly showing the positive impact of the GZD project/intervention on wheat productivity in the command area.

**Table-2**

*Comparison of Wheat (Yield Kg/acre) before and after GZD-CADP in Dera Ismail Khan and Tank Districts*

| | *M* | *SD* | $\bar{d}$ *(95% CI)* | *t-value (p)* |
|---|---|---|---|---|
| Wheat Pre-intervention | 401.40 | 21.29 | -856.92 [-911.98,-801.87] | -31.33 (0.00) |
| Wheat Post-intervention | 1258.3 | 183.18 | | |

**Note: df = 46,** $s_d$ **= 27.35**

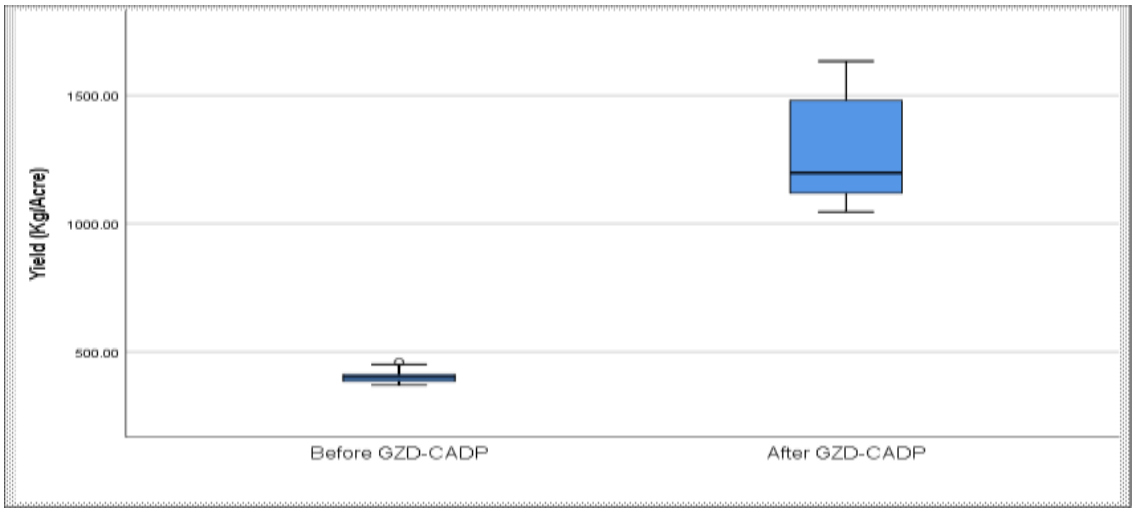


*Figure-3: Box-Plot Showing Wheat Yield Before and After GZD-CADP in Dera Ismail Khan and Tank Districts*

To assess whether the net income of wheat yield (Rs/Acre) differs before and after the initiation of GZD-CADP in Dera Ismail Khan and Tank Districts, the results showed that the average wheat yield income (per acre) after initiating GZD-CADP is higher than the average wheat yield income before GZD-CADP. The results of the paired t-test showed that the average wheat yield income significantly increased after initiating GZD-CADP compared to before the proposed intervention in the command area: $M_{\text{before GZD-CADP}}$ = 17875.83 Rs/acre ($SD_{\text{before GZD-CADP}}$ = 1149.86), $M_{\text{After GZD-CADP}}$ = 46304.69 Rs/acre ($SD_{\text{After GZD-CADP}}$ = 10441.19), $t$ (46) = -18.26, and $p < 0.05$ (see Table 3). The same evidence is provided by Figure 4.

**Table-3**

*Comparison of Wheat Income (per acre) before and after GZD-CADP in Dera Ismail Khan and Tank Districts*

| | *M* | *SD* | $\bar{d}$ *(95% CI)* | *t-value (p)* |
|---|---|---|---|---|
| Income Pre-intervention | 17875.83 | 1149.86 | -28429 [-31562,-25296] | -18.26 (0.00) |
| Income Post-intervention | 46304.69 | 10441.19 | | |

**Note: Df=46, $s_d$ = 1556.64**

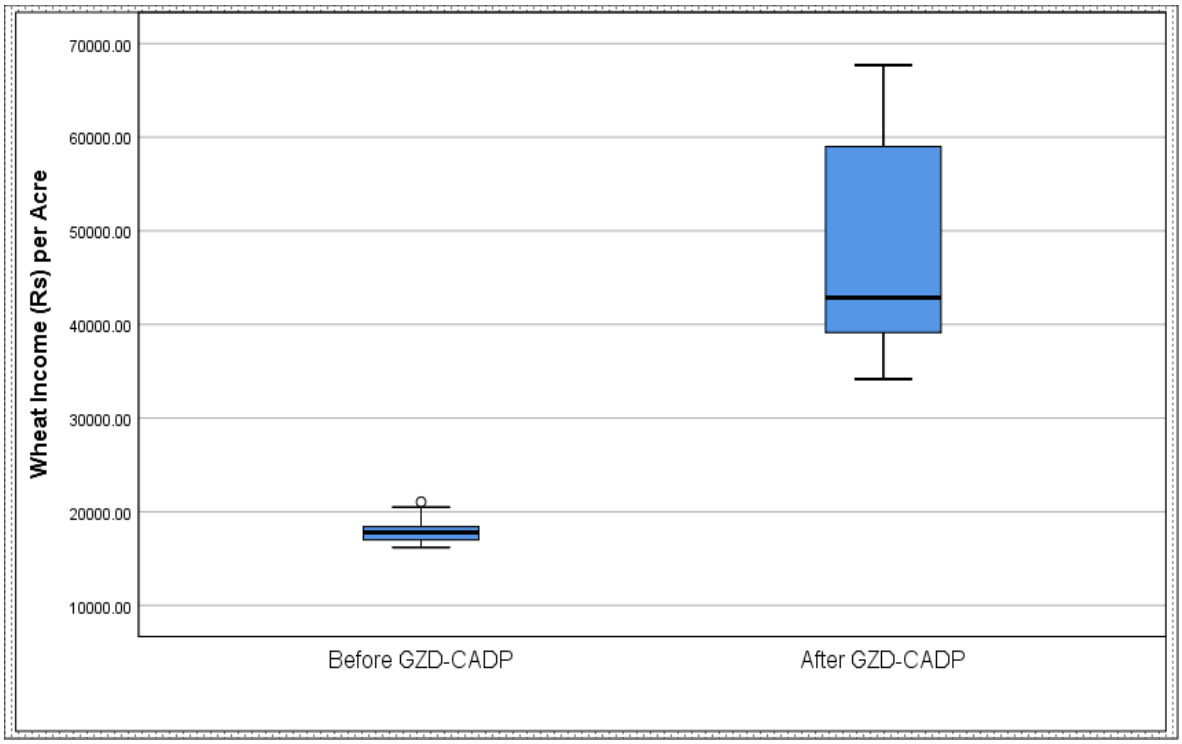


*Figure-4: Box-Plot Showing Wheat Income (Rs per Acre) Before and After GZD-CADP in Dera Ismail Khan and Tank Districts*

## CONCLUSION

Irrigation is necessary for enhancing agricultural productivity and supporting rural communities. A sufficient water supply in command areas allows farmers to cultivate more crops and increase their income. This study found that there was a significant impact of the Gomal Zam Dam Project on wheat production and its income per acre in Dera Ismail Khan and Tank Districts of Khyber Pakhtunkhwa. The wheat yield (kg/acre) significantly increased after the initiation of Gomal Zam Dam Command Area Development Project (GZD-CADP). Additionally, 47 farmers (beneficiaries) reported a dramatic increase in their wheat yield income (Rs/acre) after the initiation of the Gomal Zam Dam Project. The findings suggested that such interventions in the command areas of other dam projects completed by the irrigation department could serve as a trigger for the green revolution in the province to augment the food security policy (2021) of the provincial government.

The increase in wheat yield and income after the start of the GZD-CADP is mainly linked to the availability of reliable irrigation water. With assured water supply, farmers were less dependent on rainfall, which helped them sow wheat on time and manage their fields more effectively. Improved canal water distribution also maintained better soil moisture which leads to healthier crop growth and higher yields. However, some limitations of the study should be noted. The study was conducted with a small sample and covered only selected command areas of Dera Ismail Khan and Tank Districts, which may limit the general application of the results. Furthermore, the analysis focused only on wheat yield and income, while other crops, long-term environmental effects, and water-use efficiency were not examined.

Future research should include a larger sample size and cover other dam command areas in the province. Further studies should also assess the long-term economic and environmental impacts of irrigation projects, including cropping patterns, groundwater conditions, and climate-related risks, to better understand their role in improving agricultural productivity and food security.

## REFERENCES

Afzal, J., Yihong, Z., Qayum, M., Afzal, U., & Aslam, M. (2022). Effects of dam on temperature, humidity and precipitation of surrounding area: a case study of Gomal Zam Dam in Pakistan. *Environmental Science and Pollution Research, 30*(6), 14592–14603. https://doi.org/10.1007/s11356-022-23112-7

Ambast, S. K., Tyagi, N., & Raul, S. K. (2006). Management of declining groundwater in the Trans Indo-Gangetic Plain (India): Some options. *Agricultural Water Management, 82*, 279–296. https://doi.org/10.1016/j.agwat.2006.05.007

Ashraf, M., Kahlown, M. A., & Ashfaq, A. (2007). Impact of small dams on agriculture and groundwater development: A case study. *Agricultural Water Management*, *92*, 90-98. https://doi.org/10.1016/j.agwat.2007.05.005

Asif, M., Akbar, G., Ahmad, M. M., & Khattak, M. S. (2016). Impact of Rod Kohis improvement on water conveyance losses and wheat yield. *Journal of Himalayan Earth Sciences*, *49*(1), 110-116. https://doi.org/10.1007/s12524-016-0224-9

Bakhsh, A., Ashfaq, M., Ali, A., Hussain, M., Rasool, G., Haider, Z., & Faraz, R. H. (2015). Economic evaluation of different irrigation systems for wheat production in Rechna Doab, Pakistan: *RePEc: Research Papers in Economics*, *52*(3), 821–828. https://econpapers.repec.org/RePEc:fpr:psspwp:28

Bos, M. G., Burton, M. A. S., & Molden, D. J. (2005). *Irrigation and drainage performance assessment: Practical guidelines*. Center for Agriculture and Bioscience (CABI).

Edwards, E. C., & Smith, S. M. (2018). The role of irrigation in the development of agriculture in the United States. *The Journal of Economic History*, *78*(4), 1103–1141. https://doi.org/10.1017/s0022050718000608

FAO. (2015). *FAO statistical pocketbook, world food and agriculture.* Food and Agricultural Organization of the United Nations.

Getachew, T., Nigatu, B., Getu, D., & Getaneh, B. (2025). Effect of irrigation regime on yield and water productivity of wheat (Triticum aestivum L.) in the lowland area of Ethiopia. *Discover Sustainability*, *6*(1). https://doi.org/10.1007/s43621-025-01951-x

GoKP. (2016). *Development statistics of Khyber Pakhtunkhwa.* Bureau of Statistics, Planning and Development.

Hazell, P. B. R. (2009). The Asian green revolution. International Food Policy Research Institute (IFPRI) Discussion Paper 00911.

Jin, S., Yu, W., Jansen, H. G., & Muraoka, R. (2012). The impact of Irrigation on Agricultural Productivity: Evidence from India. *AgEcon Search (University of Minnesota, USA)*. https://doi.org/10.22004/ag.econ.126868

Khan, H., & Shah, M. (2012). Irrigation, farm productivity and poverty reduction in KPK: Understanding direct and indirect impacts and linkages. *Procedia Economics and Finance*, *2*, 292-298. https://doi.org/10.1016/S2212-5671(12)00073-5

Khan, S. A., Shah, S. A., Ullah, I., Ibrahim, M., & Khan, S. (2018). Impact of Gomal Zam Dam irrigation project on agriculture and welfare of farming community in southern districts of Khyber Pakhtunkhwa-Pakistan. *Asian Journal of Agriculture and Rural Development*, *7*(10), 212–218. https://doi.org/10.18488/journal.1005/2017.7.10/1005.10.212.218

Nasir, M. J., Rahman, A. U., & Khan, A. S. (2021). Assessment of irrigation development in the small Dams command area: a case study of Palai Dam, District Charsadda. *Sarhad Journal of Agriculture*, *37*(1). https://doi.org/10.17582/journal.sja/2021/37.1.43.51

Qureshi, M., & Hanjra, M. A. (2010). Global water crisis and future security in an era of climate change. *Food Policy*, *35*, 365–377. https://doi.org/10.1016/j.foodpol.2010.04.001

Ren, K., Wang, Z., Wu, J., Zhao, K., Huang, M., & Li, Y. (2025). One−off irrigation enhances wheat yield and water productivity: Evidence from meta−analysis and a three−year and three−site field experiment. *Agricultural Water Management*, *317*, 109628. https://doi.org/10.1016/j.agwat.2025.109628

Rizwan, M., Bakhsh, A., Li, X., Anjum, L., Jamal, K., & Hamid, S. (2018). Evaluation of the impact of water management technologies on water savings in the Lower Chenab Canal Command Area, Indus River Basin. *Water*, *10*(681), 1-18. https://doi.org/10.3390/w10060681