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Inefficient Irrigation Infrastructure in Pakistan

Food security is based on four factors: availability, access, utilization, and stability. Pakistan is ranked 109th out of 127 on the 2024 Global Hunger Index (Pakistan, n.d), primarily due to availability and stability. One of the major contributors to their insecurity is unsustainable systems for agriculture. The irrigation systems of Pakistan are a weakness in their agricultural sector, which is a major driving force behind their extreme food insecurity.

Being located on the coast of Southeast Asia allows for Pakistan to utilize the Indian Ocean as well as the expansive Indus River Delta for their farming systems. Pakistan generally experiences variance in seasons with a rainy season through the summer where they are especially susceptible to monsoons (Pakistan at a Glance, n.d). Out of the 77,087,500 hectares of land, 31.26% (24,100,000 hectares) of Pakistan is cultivated (Pakistan at a Glance, n.d). On average, each farm is about 1.82109 hectares (Pakistan Bureau of Statistics, n.d., p. 72); for reference purposes, an average farm is about one standard baseball field or a New York City block. For the typical small-scale farmer, this plot is their sustenance. Often, to divided to make the large investment of HEIS feasible. This constraint is an excellent example of how any major infrastructure updates must be phased in. Their total population is rounded to 257,000,000 people (Pakistan at a Glance, n.d Of the total population, around 36.9% is considered to be food insecure. Regardless of this insecurity, agriculture is a main contributor of the country's gross domestic product. Sugarcane and cotton production account for 1.2% of the country's

total gross domestic product (Pakistan at a Glance, n.d). Additionally, 48% of total cultivated area is used to grow either rice or wheat (Pakistan at a Glance, n.d).

Pakistan's agricultural systems are inefficient and lead to considerable harvest loss, a main contributor to food availability and stability. Due to the geography of Pakistan, a large amount of the irrigation in their agriculture is reliant on the Indus river. Approximately 70-80% of farmland relies on what's known as the Indus Basin Irrigation System (IBIS) (Rehman et al., [27]). Pakistan is vulnerable to monsoons and similar natural disasters of such. Furthermore, Pakistan has been ranked the 8th most vulnerable country to climate change (Pakistan, n.d), meaning they are likely to experience symptoms of global warming, such as sea level rise, warmer temperatures and increased droughts. As can be imagined, any failure in this type of river based irrigation system will result in significant crop loss. A well known instance of this was in 2010, when the Indus river faced massive flooding. These floods triggered a humanitarian crisis; approximately 2.2 million hectares of crops were destroyed, causing nationwide food shortages and economic despair (Britannica, 2023). Even when without failures, this system has many other flaws. The Indus Basin Irrigation System is extremely variable in its distribution of water output through differing outlets (Nabi et al, 2024). This leads to instability in food supply throughout the country. Large amounts of harvest loss are detrimental to the entire population. Harvest loss is the depletion of crops due to irrigation, infrastructure, disease, soil, and pest issues. (Junaid et al., 2024) By lowering the amount of food available due to harvest loss, many are unable to afford lofty food prices or there is physically a shortage of food. Moreover, the stability of nutrition is also decreased. Both of these pillars are key to a food secure society, without them Pakistan will continue to face malnutrition, stunted growth in children, and chronic ailments. The Pakistani government has recognized and began to take steps towards reducing this issue by implementing a *More Crop Per Drop* strategy, "Within the ['More Crop per Drop' strategy] the NWP mandates banning flood irrigation nationally and introducing

high efficiency irrigation systems (HEIS) to save water. The concept of water use efficiency (WUE) and the impact of replacing flood irrigation with HEIS on basin-wide water use are contested in the context of Pakistan." (Drew & Crase, 2023). These efforts were all included in Pakistan's National Water Policy (2018). While they are steps in the right direction, there is no real change being made; in reaction a system must be launched to improve this.

There are many feasible solutions to help repair these systems and ultimately increase agricultural productivity. These solutions include utilizing high efficiency irrigation systems, making improvements to current canal infrastructure, utilizing dams, and increasing crop diversity. High efficiency irrigation systems come in many different forms including: drip, sprinkler, and centre pivot. Each has its own variances but typically these types of systems face high purchase and installation costs. However, they provide extremely efficient water use and can be suitable for most any terrain as long as the correct type is selected. (Huskins 2024) In comparison, canal repairs, such as lining channels with concrete to reduce seepage, does not require new infrastructure but only solves a small portion of crop losses. Dams, can fully support agricultural needs throughout climate changes; however, they have massive upfront costs and environmental impacts. Due to these flaws, neither of these options are truly viable. Another strategy is diversifying crops. By having a variety of water intensive and non-water intensive crops, farms can increase product through droughts and other climate conditions. Crop diversification has many other benefits to the farm including bettering soil health and expanding the variation of income. It is important to note that most primary crops in Pakistan are very water demanding, making the switch to more efficient crops may be difficult to integrate into the market. Although, with slow integration of this strategy, that may be remediated. This resolve would happen with the implementation of some form of economic benefit for farmers such as a tax credit.

The first step Pakistan can take is the choice with the lowest upfront costs: adding non-water intensive crops such as sesame and maize to existing crop rotations (Anderson, 2021). Since this strategy uses resources and tools smaller farms already have, this initiative is able to be quickly enacted. Diversifying away from water intensive crops allows for some lessening in harvest loss due to water access instability. Additionally, this would also help stabilize the local food supply and the farm's income, while providing enrichment to the soil. Crop diversification is not a permanent substitute for modernizing irrigation. The addition of crop diversification is a beneficial way to transition to high efficiency irrigation systems.

Step 2 is a full transition to high efficiency irrigation systems (HEIS), but rolling HEIS out nationwide all at once is not realistic. A survey of 242 Punjab farmers, manufacturers, and officials identified five recurring barriers to adoption: high upfront capital cost relative to smallholder income — the single most-cited constraint, reported by over 90% of non-adopters in some zones — the reliability of the power supply HEIS depends on, farmer distrust built from systems that were installed and later abandoned, land fragmentation — small landholdings are a documented barrier to adoption (Bakhsh et al., 2020), and the average Pakistani farm is only about 1.82 hectares (Pakistan Bureau of Statistics, n.d.), limiting the economies of scale needed to justify installation — and a shortage of extension and repair infrastructure to train farmers on the new systems (Bakhsh et al., 2020). Rather than treating these barriers as reasons to delay, Pakistan should address them directly through a pilot-and-scale approach. The government should build on infrastructure that already exists — the Punjab Irrigated-Agriculture Productivity Improvement Project (PIPIP) already subsidizes 60% of HEIS installation cost and 80% for solar-powered systems — rather than starting a new program from zero (Bakhsh et al., 2020). A first phase should target high-value, water-intensive farms such as orchards and cotton, where drip irrigation paired with tunnel farming has been shown to generate Rs. 1.24–1.98 million per hectare annually, giving farmers a fast, visible return that builds trust before wider rollout (Bakhsh et al., 2020). Pairing

every new system with a solar-powered pump from installation, rather than retrofitting later, removes the energy bottleneck before it becomes one. Bundling installation with the existing subsidy and low-interest loan programs keeps the upfront cost from falling on the farmer alone, and organizing installation through farmer cooperatives and demonstration plots gives neighboring farmers a low-risk way to see the system work before committing their own land. This sequencing is supported by the same research: farmers with regular contact with professionals and access to trained labor were significantly more likely to adopt and sustain HEIS use (Bakhsh et al., 2020). Combined with the crop diversification already underway in Step 1, this phased approach lets Pakistan build toward full high efficiency irrigation system adoption without requiring every farmer to absorb the full cost and risk on day one.

In conclusion, much of Pakistan's food insecurity is caused by inefficient and fragile agricultural irrigation systems, which are heavily impacted by climate shocks. Given that Pakistan is climate-vulnerable, it is essential that a phased combination of high efficiency irrigation systems and agricultural diversification be integrated into their food system. The increase of food stability and accessibility that this combination provides will help Pakistan work toward a more food secure future. There are multiple factors impacting the food insecurity of Pakistan, however making changes within their agricultural sector is one of the more realistic moves towards resolving this issue. Poverty, governmental issues, conflict, and more are common causes of food insecurity, but they are all part of a broader context. These factors are not as able to be worked with due to their large-scale nature. The repair of Pakistan's irrigation systems will ultimately provide the most impactful intervention to their food insecurity.

Works Cited:

Anderson, B. (2021). Smart Water Use on Your Farm or Ranch Water-Conserving Plants. Sustainable Agriculture Research and Education. Retrieved January 31, 2026, from https://www.sare.org/

wp-content/uhttps://www.sare.org/publications/smart-water-use-on-your-farm-or-ranch/plant-management/water-conserving-plants/ploads/Smart-Water-Use-on-Your-Farm-or-Ranch.pdf

Bakhsh, A., Ali, A., Chauhdary, J. N., Hussain, M., & Aslam, F. (2020). Adoption of high efficiency irrigation system (HEIS) in Punjab, Pakistan: Challenges and options. Pakistan Journal of Agricultural Sciences, 57(5), 1303–1315. https://doi.org/10.21162/PAKJAS/20.9343

Bandaragoda, D. & Ur Rehman, Saeed. (1995). Warabandi in Pakistan's Canal Irrigation Systems: Widening Gap between Theory and Practice.

"Barriga Cabanillas, Oscar; Farooq, Marziya; Meyer, Moritz; Wieser, Christina. 2025. When Does a Village Become a Town? Revisiting Pakistan's Urbanization Using Satellite Data. Policy Research Working Paper; 11247. © World Bank. http://hdl.handle.net/10986/43926 License: CC BY 3.0 IGO."

Britannica Editors (2023, March 21). Pakistan Floods of 2010. Encyclopedia Britannica. https://www.britannica.com/event/Pakistan-Floods-of-2010

Drew, M., & Crase, L. (2023). 'More crop per drop' and water use efficiency in the national water policy of pakistan. Agricultural Water Management, 288, 108491. https://doi.org/10.1016/j.agwat.2023.108491

Government of Pakistan Ministry of Water Resources. (2018, April). National Water Policy. Retrieved January 29, 2026, from https://faolex.fao.org/docs/pdf/pak181229.pdf

Huskins, C. (2024, June 25). The Pros and Cons of Different Irrigation Systems: Which One Is Right for Your Farm? ReAg Tools. https://reagtools.co.uk/blogs/news/ the-pros-and-cons-of-different-irrigation-systems-which-one-is-right-for-your-farm?srsltid=AfmBOoqtwKNnJpuCtuOeLvuBriNpEuBSXuhERoL7onWBmfttHc3alFqP

Junaid, M., & Gokce, A. (2024). Global Agricultural Losses and their Causes. Bulletin of Biological and Allied Sciences Research, 2024(1), 66. https://doi.org/10.54112/bbasr.v2024i1.66

Nabi, G., Hussain, F., Sajjad, B., Masood, M., & Liu, D. (2024). Performance evaluation of irrigation outlets with physical model study in indus basin irrigation system of pakistan. Environmental Monitoring and Assessment, 196(12). https://doi.org/10.1007/s10661-024-13454-9

Pakistan [Fact sheet]. (n.d.). World Food Program. Retrieved January 28, 2026, from https://www.wfp.org/countries/pakistan

Pakistan at a Glance [Fact sheet]. (n.d.). Food and Agriculture Organization of the United Nations. Retrieved January 28, 2026, from https://www.fao.org/pakistan/our-office/pakistan-at-a-glance/en/

Pakistan Bureau of Statistics. (n.d.). 7th Agricultural Census of Pakistan 2024 Integrated Digital

Count Main Findings Report (A. Iqbal & A. M. Sumra, Authors; Report No. 7). https://www.pbs.gov.pk/wp-content/uploads/2020/07/Agricultural_Census_Main_Findings_Report.pdf

PIPS SDGs Desk. (2024). *WATER SCARCITY AND WASTAGE IN PAKISTAN*. https://www.pips.gov.pk/wp-content/uploads/2024/09/WATER_SCARCITY_AND_WASTAGE_IN_PAKISTAN.pdf

Thirsty Crops. (n.d.). Worldwide Wildlife Foundation (WWF). https://assets.wwf.org.uk/downloads/thirstycrops.pdf