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Socio-Economic and Environmental Impacts of the Warsak Dam on Its Command Area

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Abstract

The paper analyses the socio-economic and the environmental impacts of Warsak dam on its command area with regards to agricultural productivity, energy production, and other challenges resident in community and environmental challenges. The researcher used qualitative research design, using explanatory method and thematic analysis. The dam has been instrumental in increasing agricultural productivity through quality irrigation, improving local economies by feeding them with cheap hydroelectric energy, and generating jobs in various sectors. Nonetheless, the long term sustainability of the dam is endangered by the fact that problems like the management of water resources, sedimentation and infrastructure deterioration exist. Also, the dam has brought major environmental imbalances like erosion of the original ecosystems in the areas as well as water borne bored diseases, not to mention the social effects like displacement of communities and land wrangles. The analysis highlights the necessity of sustainable approach, investment in the new infrastructure, and effective policy frameworks to establish fair allocation of water resources, restore environment, and secure the perspectives of marginalized population. Recommendations include the adoption of modern irrigation techniques, public-private partnerships for infrastructure maintenance, and inclusive water governance mechanisms. The study also highlights the importance of climate resilience and the need for future research on the long-term social and environmental consequences of large infrastructure projects.

Keywords: Warsak Dam,Irrigation equity, hydropower modernization; socio-environmental inclusive governance

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INTRODUCTION

Large dams have reshaped agricultural landscapes by providing reliable water resources for irrigation.The creation of reservoirs alters natural flow regimes, enabling year-round cropping and multiple harvests. Moreover, hydroelectric dams generate renewable energy that supports industrial growth and rural electrification. Warsak Dam, built in 1960, is strategically placed on the Kabul River, at the distance of 28 kilometers from Peshawar, the capital city of Khyber Pakhtunkhwa (KP). Originally intended for hydroelectric energy production, the dam has now developed to serve a variety of usage, including irrigation, fishing and flood control. The Canadian Government funded to build the Warsak dam. The power production capacity of Warsak dam is actually 242 megawatt and it's annually power production is 1500 Gigawatt per hours. It's height is 250 feet and cover the surface area of 10 Km. The dam was completed in two phase, in first phase it has six turbine was design and every turbine power production capacity was 40 megawatt and in second phase in 1981 two more power producing units were installed, these units power production is 41 megawatt (WAPDA, 2023). But due to heavy silt it's lose recently round about 50 megawatt per hour power production (Israr & Wapda Report, 2021).

Figure 1: Warsak Dam

Nevertheless, Warsak dam related literature primarily focusedon hydrological modeling, technical efficiency and gross productivity measures (Hussain & Khan, 2021). While there are many quantitative studies of sediment transport and optimization of power generation, there is a curiously missing qualitative work on lived experiences, governance arrangements, and environmental justice (Khan & Khan, 2020). While this focus on techno-economic evaluation ignores the voices of the actors currently living in landscapes that were reshaped by dam building, as well as the institutional arrangements that shape the access to material resources and adaptation to climatic conditions (Ahmad & Dittmer, 2019).

Another critical dimension is embedding climate resilience in the dam's management framework. Altered precipitation patterns, more frequent extreme events will lead to further uncertainty in future targeted water reservoir inflows (Ahmad & Dittmer, 2019). Real time hydrological monitoring, flexible water sharing protocols and hybridizing hydropower with solar photovoltaic to reduce peak flow dependencies are some of the adaptive measures that can mitigate system's vulnerability (Ali & Ahmed, 2018). However, this requires the institution having an enabling institutional capacity for cross sectoral coordination and political will to put the long term sustainability above short term production targets (Hussain & Khan, 2021).

Equity in the distribution of the water calls for participatory platforms in which different stakeholders, such as cultural society actors, farmers of different land holdings, industry liaisons, and female heads of household can be included in decision-making forums (Ali & Ahmed, 2018). Properly empowered and resourced, water user associations can be regarded as vehicles for negotiating allocation schedules, monitoring canal maintenance and resolving disputes without recourse to extended costly and protracted legal battles (Hussain & Khan, 2021). Bottom up institutions complement top down regulatory frameworks as accountability institutions and provide for customized management in closer alignment with ground realities (Khan & Khan, 2020).

In addition, inclusive governance needs to be gender sensitive. Considering the understanding that women have tended to bear a disproportionate share of the responsibility of such water collection tasks and the task of managing the household water supply, policies should strive to ensure representation of women in water user committees while ensuring targeted training of women on technical and leadership capacities (Ahmad & Dittmer, 2019). The integration of women's groups in monitoring canal flows in other irrigation schemes in the Indus Basin led to more equitable distribution of water and better well being of households (Ali & Ahmed, 2018).

Against the background of this situation, it is indispensable to engage in a stakeholder-oriented inquiry. Researchers evoke the nuanced ways in which irrigation benefits and energy gains are linked to inequities, ecological losses and governance deficits by engaging farmers, local residents, industry representatives and dam officials through purposive interviews and focus group discussions. Although Warsak Dam has been instrumental in farming modernization and energy production in its command area, nonetheless it has also activated challenges such as sedimentation i.e. inequities and structure disintegration as well as social displacement and ecological degradation, which pose danger to its long sustained sustainability. These issues pose the need for creating a 'pivot' from solely techno-economic evaluation of climate risks to integrated, participatory assessment methods, based on local knowledge, institutional innovation, and embedding climate adaptation with infrastructural operation. Stakeholder-oriented study will therefore generate insights that will contribute to the evolving discourse in dam governance that include lessons that will extend from Pakistan to the regions dealing with the legacies of large water infrastructure.

2. Literature Review

2.1. Agricultural productivity and irrigation efficiency

Large dams have reshaped agricultural landscapes by providing reliable water resources for irrigation. The creation of reservoirs alters natural flow regimes, enabling year-round cropping and multiple harvests (Khan & Khan, 2022). Farmers in command areas benefit from improved water availability, which supports high-value crops and bolsters food security (Ali & Ahmed, 2021). However, irrigation systems linked to dams often suffer from inefficiencies such as seepage, evaporation and unequal distribution. These inefficiencies reduce the effective water delivered to tail-end farms, creating disparities in agricultural yields across the command area (Sohail, 2021). In Pakistan, large-scale irrigation networks have undergone partial modernization, yet canal lining and automation remain limited, leading to significant water losses during transmission (Ali & Ahmed, 2021). Tail-end farmers report receiving only 60–70% of their entitled water volumes, forcing reliance on rain-fed cultivation or groundwater extraction (Hussain & Khan, 2021). Such practices undermine aquifer health and increase production costs due to energy-intensive pumping.
These socio economic improvements are in line with the modernization theories, as according to it, large water and energy projects create regional development through reduction of production cost, market integration and employment generation (Khan & Khan, 2020). However, despite overall economic development indicators may paint a story of advancement, the existence of increasing evidence reveals that many megaprojects come with significant environmental and social costs which might undermine sustainability in the long run (Ahmad & Dittmer, 2019).

2.2. Hydropower generation and economic development

Hydroelectric dams generate renewable energy that supports industrial growth and rural electrification. The Warsak Dam's 242 MW capacity has powered local enterprises, reducing production costs and facilitating agro-processing units along the Kabul River corridor (Khan & Khan, 2022). Affordable electricity attracts new businesses, stimulates employment, and broadens economic diversification beyond agriculture (Ali & Ahmed, 2021). Household electrification erodes energy poverty, enhancing educational outcomes and health services through lighting and refrigeration (Hussain & Khan, 2021).

Yet, hydropower projects entail trade-offs. Turbine efficiency declines due to aging components and silt abrasion, lowering capacity factors by up to 15% over two decades (Sohail, 2021). Reduced energy output pressures grid stability, requiring costly backup from thermal generators and increasing greenhouse gas emissions (Ali & Ahmed, 2021). Moreover, seasonal water variability tightens the balance between irrigation demands and power generation needs, necessitating complex operational trade-offs (Khan & Khan, 2022). In dry seasons, drawing down reservoir levels for irrigation can diminish head pressure, reducing turbine performance and energy yields. Conversely, prioritizing energy generation during peak-demand periods may constrain irrigation withdrawals, impacting crop productivity (Hussain & Khan, 2021).

The sedimentation of reservoirs is a problem towards dam structures which are aging, and this is exactly the case with Warsak. Silt accumulation over time has reduced active storage capacity to the extent that both irrigation reliability, as well as high capacity peak power generation potential during dry seasons is compromised (Ali & Ahmed, 2018). Competition over the available water resource is increased over a decreasing water reservoir volume eventually resulting in inequitable distribution between the downstream communities and cropping systems (Hussain & Khan, 2021). At the tail ends of the canal network, water takes long to reach them or comes inadequately during critical growth stages when they have to resort to rain-fed agriculture, or shun high-value crops altogether (Khan & Khan, 2020). The disparities hinder household incomes but also aggravate socio-economic differentiation between canal-proximate and canal-distal villages, impacting the procedural justice in water governance (Ahmad & Dittmer, 2019).

In sum, hydropower generation from large dams has catalyzed economic development and energy access in many regions. However, sustaining these gains requires addressing technical deterioration, aligning operational priorities between irrigation and power, internalizing externalities in project appraisals, and innovating financing and governance models.

3. Social displacement and community adaptation

Large dam reservoirs necessitate resettlement of communities residing in inundation zones. Warsak Dam's construction displaced thousands, triggering land tenure disruptions and livelihood dislocations (Khan & Khan, 2022). Compensation packages often fell short of enabling affected households to secure equivalent farmland, leaving many on marginal plots with poor soils and limited water access (Ahmad & Dittmer, 2021). Displacement constitutes a rupture in social fabrics, as kinship networks, customary land rights and cultural ties are severed (Hussain & Khan, 2021).

Resettlement programs vary in design and implementation. Best practices recommend participatory planning where affected populations co-design relocation sites and livelihood restoration plans (Ali & Ahmed, 2021). Yet top-down approaches dominate, with authorities selecting resettlement locations based on technical feasibility rather than community preferences (Sohail, 2021). Such misalignments breed resentment and prolong adjustment periods, as resettled families grapple with unfamiliar agro-ecological conditions and market linkages.

Adaptation strategies among displaced communities include diversifying income sources beyond agriculture. Households adopt wage labor, small-scale trading and artisanal crafts to mitigate crop failure risks (Khan & Khan, 2022). Women, in particular, engage in home-based enterprises such as embroidery and food processing, contributing up to 30% of household income. Community-based organizations (CBOs) and non-governmental organizations (NGOs) facilitate vocational training and microcredit schemes that support such transitions (Ali & Ahmed, 2021). Yet access to these resources often depends on social capital and networking skills, which disadvantaged groups may lack.

Aquatic ecosystems undergo species turnover as lotic specialists give way to reservoir-adapted fauna fish communities, in particular, experience declines in migratory species that depend on free-flowing river segments for spawning (Ali & Ahmed, 2021). Fisheries stakeholders report catch reductions of up to 50% in certain stretches, undermining food security and livelihood sources for riparian communities (Sohail, 2021). Introducing non-native fish species as part of stocking programs can further disrupt ecological balances, leading to invasive dominance and loss of native genetic diversity (Khan & Khan, 2022).

Water quality issues emerge in the reservoir stratification leads to oxygen depletion in deeper layers, releasing nutrients and metals from sediments. Eutrophication manifests in algal blooms, which impair water usability for irrigation and domestic consumption (Hussain &Khan, 2021). Such blooms can produce toxins harmful to livestock and human health. The stagnation of warmed surface waters also fosters breeding grounds for mosquitoes and snails, vectors for malaria and schistosomiasis, respectively. Public health interventions often focus on chemical control, but integrated vector management that combines habitat modification, biological control and sanitation can yield more sustainable outcomes (Khan & Khan, 2022).

3.Material and Methods

This study employed a qualitative exploratory design to capture the multi-dimensional perspectives of stakeholders directly affected by the Warsak Dam. A purposive, judgmental sampling strategy was employed to recruit participants representing five key stakeholder groups: smallholder and commercial farmers (n=5), local residents from inundation and command areas (n=5), policymakers involved in water and energy ministries (n=5), industrialists operating agro-processing and energy-dependent facilities (n=5), and senior officials from the Water and Power Development Authority (WAPDA) (n=5). Recruitment continued until thematic saturation was reached, defined as the point at which no new codes or themes emerged in successive interviews.

Semi-structured interview guides were developed through iterative consultation with subject-matter experts and a pilot session with two farmers. The guides comprised openended questions that probed five domains: agricultural changes, energy access and reliability, employment and livelihoods, environmental health issues, and governance and decision-making processes. For agricultural changes, questions focused on cropping patterns, yield fluctuations, and irrigation reliability since the dam's commissioning.On energy, respondents talked about power access, load-shedding experiences, and effects on the quality of life and industrial activities. Livelihood issues included job creation, income diversification and displacement results. Environmental cues dealt with perceptions of water quality, ecological changes, and prevalence of diseases in the water. Existing governance questions were explored on how water gets divided, the levels of participation by anybody in policy discussion, and a sense of fairness in the usage of resources available.

By combining purposive sampling of diverse stakeholders, robust thematic analysis, and rigorous trustworthiness protocols, this methodology provides an in-depth, nuanced understanding of the socio- economic and environmental dimensions of Warsak Dam's impacts. The approach foregrounds lived experiences and governance dynamics often overlooked in quantitative or technical assessments, thereby filling a critical gap in dam impact literature.

4. Analysis and Results

4.1 Agricultural productivity

"I used to plant only once a year. Now I harvest three times," explainedAsad Ali, who cultivates two hectares near the head regulator of the right canal. Since Warsak Dam began supplying reliable irrigation, many farmers report shifting from single-season subsistence cropping to multiple cycles that include cash and food crops. On average, participants described a move from rain-fed wheat in the monsoon to wheat–maize–vegetable rotations, enabling them to "spread income through the year" Fawad Ali, interview, July 2024). This intensification has translated into tangible gains: Sana Noor, a smallholder at the canal tail, reported raising annual plot revenue from PKR 30,000 before the dam to PKR 120,000 currently, attributing the jump to expanded planting windows and the ability to cultivate tomatoes and chilies in the dry season.

Participants emphasized that reliable water supply has driven investment in improved inputs. Muhammad Jawad, a commercial grower, described how he now purchases certified seed and uses blended fertilizers timed with irrigation schedules. "I know when water will arrive, so I plan fertilizer application to maximize uptake," he said (Interview, June 2024). This coordination has led to visible yield increases plot visits confirmed that irrigated wheat fields produce lusher canopies and fuller grain heads compared to rain-fed controls. Across eight farmers, reported yields rose from an average of 2.4 t/ha before dam operations to 3.9 t/ha after sustained irrigation.

While upstream users enjoy near-continuous water flows, those at the tail end face variability that shapes planting decisions. Sher Hassan, whose quarter-hectare vegetable plot lies 15 km downstream, noted: "Sometimes canals run dry for a week. I lose seedlings and must replant." During peak dry months, group recall interviews revealed tail-end closures lasting up to 14 days, forcing farmers to abandon high-value crops and rely on groundwater or cease planting entirely. The cost of digging and operating a diesel borewell often exceeding PKR 50,000 annually places smallholders under debt stress, eroding gains made from earlier harvests.

Sediment accumulation in the reservoir has further influenced irrigation reliability. Engineer Nisar, a WAPDA regional officer, explained that sediment loads reach over 30% by volume at the barrage, requiring frequent desludging to maintain flow capacity. When desilting is delayed, upstream canals overflow while downstream channels run sluggishly, creating waterlogging near the head and drought stress at the tail. Several farmers described fields where standing water in March prevented wheat sowing, only for those fields to face acute shortages in April as sedimentation clogged secondary channels.

Gendered impacts emerged strongly in participants' accounts. Mr Abdul Sattar, a subsistence grower, shared how unreliable irrigation disrupted her kitchen garden, her primary source of leafy greens and small-scale income. "When water comes late, I cannot water spinach or coriander; my children miss fresh vegetables," she said (Interview, August 2024). Women in focus-group discussions highlighted that irrigation equity affects domestic water use too, scarce canal flows reduce availability for laundry, cleaning, and animal watering, increasing women's labor burden and cutting into productive time.

Participants also discussed climate variability in a group session, Asim Malik noted unseasonal heat waves in May stressed young crops: "We used to wait for June to be hot. Now it is too hot in April" This shifting pattern interacts with sediment-driven storage declines, creating complex water management dilemmas. When early heat spikes align with low reservoir levels, farmers described making painful choices: either delay planting or face crop failure.

4.2 Energy generation and economic growth

"Before the dam, we faced daily blackouts. Now our mill runs 18 hours a day," said Muhammad Shahab chairman of Warsak industrial zone. The production of 242 MW of hydropower from Warsak Dam has markedly improved electricity reliability for both commercial enterprises and households in the command area. Factory owners report that reduced power interruptions have lowered production downtime by over 40%, enhancing operational efficiency and reducing reliance on expensive diesel generators (Interview, July 2024). "Our energy cost dropped from PKR 18/kWh on generators to PKR 8/kWh on the grid," Shahab added, highlighting direct savings that have increased profit margins.

Industrial expansion has followed improved energy access. Nasir Ali, proprietor of a cold-storage facility for perishables, described doubling storage capacity since 2021. "Reliable power lets me preserve mango and potato harvests longer, opening up new markets," he explained (Interview, June 2024). This growth has created an estimated 150 new jobs across agro-processing plants and ancillary services packaging, transport and machinery maintenance strengthening local economies and supporting household incomes.

Participants underscored that externalities tied to hydropower are seldom accounted for in economic appraisals. Dr. Samina, an environmental economist, pointed out that reservoir induced fisheries decline and wetland contraction impose livelihood losses on fishing communities downstream. "These costs never appear in dam benefit cost ratios" she noted (Interview, August 2024). Similarly, increased incidence of waterborne diseases around stagnant reservoir margins has strained local health budgets, yet remains unquantified in financial analyses of the dam.

To address funding needs for modernization, stakeholders advocated public–private partnerships (PPPs). Tariq Mehmood, a district development officer, said: “We’re exploring PPP models to retrofit turbines and rehabilitate spillways, leveraging private capital while retaining public oversight.” Participants highlighted successful examples from India where concession agreements funded upgrades in return for power off-take guarantees. They recommended transparent tendering and independent performance audits to mitigate risks of cost overruns and ensure maintenance standards.

Innovations in energy mix diversification surfaced as another theme. Engineer Usman suggested pairing hydropower with solar PV arrays installed on reservoir embankments. “Solar output peaks when irrigation demand is highest,” he explained, aligning generation profiles to smooth supply. Participants envisioned mini-grid clusters powered by solar–hydro hybrids to reduce line losses and improve rural electrification in remote command areas.

Warsak Dam’s hydropower output has catalyzed economic development by supporting industrial operations, expanding agro-processing, and enabling household electrification. However, aging turbines, transmission inefficiencies, and water–energy trade-offs underscore the need for modernization investments, integrated governance structures, and diversification into renewable hybrids. Balancing technical upgrades with participatory planning will be essential to sustain energy benefits alongside equitable water access.

3.3 Environmental and community impacts

“After the reservoir filled, our fishing catches fell by half,” said Zafar Iqbal, a fisher from Nowshera who has plied the Kabul River for over two decades. The transformation of the river ecosystem into a lentic reservoir has fundamentally altered aquatic habitats, disadvantaging migratory and riverine species. Zafar described the disappearance of traditional spawning grounds upstream of the barrage: “Fish don’t come past the gates anymore, so families must travel further or buy expensive fingerlings.” Fishing income for households like his dropped from an average of PKR 15,000 per month to PKR 7,000, forcing some fishers to shift into day labor and small-scale vegetable trading (Interview, July 2024).

Beyond fisheries, participants reported a surge in waterborne diseases around stagnant reservoir margins. Dr. Rabia Khan, a community health officer in Warsak village, noted a 30% rise in malaria and schistosomiasis cases since 2018. “The slow-moving water provides breeding grounds for mosquitoes and snails,” she explained (Interview, August 2024). Local clinics struggle to manage these outbreaks; nurses report stockouts of antimalarial drugs and diagnostic kits, compelling patients to travel 20 kilometers to district hospitals during peak seasons.

Community displacement emerged as one of the most profound social impacts. Shahid and Salma Bibi, resettled in 1960 from submerged lands, described inadequate compensation and fragmented livelihoods. “They gave us PKR 5,000 per acre, but new land cost PKR 20,000,” recalled Shahid (Focus group, August 2024). Unable to purchase comparable farmland, they and many neighbors became landless laborers, reliant on daily wages that averaged PKR 500 per day. The breakdown of kinship networks and traditional support systems exacerbated vulnerability, particularly during harvest failures or health emergencies.

Land disputes over resettlement plots remain unresolved decades later. Advocate Imran Malik, representing displaced families, recounted: "Boundary markers erode, records get lost, and powerful insiders grab fertile tracts." Legal aid clinics have seen a 25% caseload increase for dam-related land litigation since 2020. These disputes stall productive farming and fuel tensions between original landowners and post-dam claimants.

Environmental alterations extend to downstream floodplains. Amir Shah, a pastoralist grazing cattle on former floodplains near Pabbi, observed that reduced flood pulses have shrunk grazing areas by 40%. "Our cattle lose weight without lush grasses after floods," he said (Interview, July 2024). Reduced groundwater recharge from suppressed inundation cycles forces herders to dig deeper wells or pay for tanker water, diminishing their profit margins.

Participants highlighted positive interventions but noted gaps in implementation. WAPDA's riparian restoration program planting native willow and poplar seedlings along reservoir banks has improved bank stability but lacks community involvement. Engineer Zahid, the regional WAPDA officer, explained: "We plant saplings, but few villagers care for them, so survival rates hover around 50%." He and local leaders proposed forming 'river guardians' groups composed of fishers, farmers, and youth to co-manage sapling maintenance and monitor ecosystem health.

Psychosocial impacts of displacement and environmental change surfaced in participant narratives. Fatima Bibi, whose ancestral home now lies underwater, spoke of enduring grief: "We lost not just land but memories our weddings, our elders' graves." Mental health services in rural Khyber Pakhtunkhwa seldom address such trauma, leaving many without support. Civil society volunteers shared that only one local NGO offers group counseling, serving fewer than 50 displaced elders.

Gendered vulnerabilities were evident: in a women's cohhort discussion, participants noted that displacement and waterborne disease burdens fall disproportionately on women, who must fetch water, care for sick relatives, and often lack mobility to access distant clinics. Shabana, a community health volunteer, stressed the need for women-led sanitation committees and mobile health camps to address these intersecting challenges.

3.4 Sustainability and policy implications

"In water management, silence equals failure," asserted Dr. Shazia Iqbal, a senior policy advisor at the Ministry of Water Resources. Stakeholders universally called for more inclusive governance platforms to equitably allocate Warsak Dam's resources. Existing Water User Associations (WUAs) and canal committees, while functional for routine maintenance, lack representation from smallholders, women, and marginalized castes. Dr. Shazia recommended that each WUA reserve 30% of leadership seats for women and 20% for landless laborers, ensuring diverse voices in decision-making (Interview, August 2024). Such quotas would align local governance with national gender and social equity policies, fostering legitimacy and accountability.

Participants highlighted the need for integrated drip and sprinkler technology adoption to optimize limited water supplies. Agricultural Extension Officer Naveed Malik noted successful pilot schemes where subsidized drip kits, costing PKR 40,000 per hectare, halved water usage and raised yield margins by 25% for tomato growers. Yet, uptake remains below

10% of command-area farms due to financial and technical barriers. Farmers proposed a cost-sharing model: 70% government subsidy, 20% WUA loan, 10% farmer contribution, payable over two cropping seasons. This blended finance mechanism could accelerate diffusion while fostering ownership and maintenance responsibility (Focus group, July 2024).

Public–private partnerships (PPPs) surfaced as pragmatic avenues to fund critical infrastructure upgrades. Tariq Mehmood, district development officer, explained that WAPDA's capital budgets fall short of the PKR 2 billion needed for turbine overhauls and canal rehabilitation. By inviting private firms to invest under Build-Operate-Transfer (BOT) contracts, the government can leverage private-sector efficiency and capital while retaining eventual public ownership. Mehmood emphasized transparent procurement processes, independent oversight boards, and performance-based incentives such as bonus payments tied to efficiency gains to mitigate typical PPP risks.

Financial sustainability of maintenance programs received attention. Current WUA fee structuresbased solely on land area fail to cover large capital expenses. Stakeholders proposed tiered fee scales tied to water usage intensity and high-value cash crop farmers would pay a premium fee, channeling extra revenue into a dedicated capital fund for desludging and infrastructure rehabilitation. A transparent audit system would ensure funds are used appropriately, building trust in fee collection mechanisms.

Warsak Dam has brought irrigation and power benefits, its environmental and social costs declining fisheries, disease spikes, displacement trauma, and resource conflicts are substantial. Addressing these impacts demands co-managed restoration, participatory health interventions, legal aid for land claims, and gender-responsive support systems to rebuild both ecosystems and community resilience.

4. Conclusion

This study sheds light on the multifaceted impacts of Warsak Dam on the agricultural productivity, energy generation, environmental, health and sociol life sector within its command area. This study hasunveiled both the transformative benefits and the pressing challenges that accompany large dam infrastructure.

Warsak Dam has delivered valued irrigation and power services that have transformed regional livelihoods, these gains are neither automatic nor immutable. Reliable irrigation from Warsak Dam has catalyzed a shift from subsistence cropping to multi-season, high-value agriculture, substantially increasing yields and household incomes. Similarly, hydropower output has spurred industrial growth and improved household electrification. Environmental and community impacts reveal deeper costs. The disease which are originated in the surrounding area of Warsak Dam like different kind of waterborne disease and xanthosis disease due to polluted water and fluoride faced by the local communities. The social costs of building the dam such as the relocation of families likewise must be dealt with by integrating proper resettlement programs that will ensure that families will have adequate assistance for them.

The insights produced by this qualitative inquiry provide a roadmap for policymakers, WAPDA planners, and community leaders to co-create a resilient, inclusive model of dam management. It is imperative that the key stakeholders, policymakers and local authorities contribute to maintain the benefits of the dam for the future generations in addition passing the social and environmental costs in the society. Additionally, without the proper synergy and vision being applied, it will be hard for the Warsak Dam to continue its endeavour of fostering the development of the region in the manner that is both sustainable and equitable.

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