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Full length article

NAVIGATING SUSTAINABILITY: A COMPREHENSIVE ANALYSIS OF EIA PROCESS AND MITIGATION MEASURES AT THE KARORA HYDROPOWER PROJECT, SHANGLA, PAKISTAN

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ABSTRACT

More than 16% of the total electricity used worldwide is met by hydropower, having local to regional environmental consequences. Pakistan's Environmental Protection Ordinance (PEPO) 1983 mandated Environmental Impact Assessment (EIA). In the Shangla District, the village of Kuz Kana is located about 300 meters upstream of the run-of-river project known as the Karora Hydropower project. The study reviewed the Environmental Impact Assessment and mitigating methods for the Karora hydropower project, Shangla, Pakistan. The authors analyzed the impact area, land resources, water resources, flora and fauna, and the Socio-Economic setup of district Shangla. They also consulted with stakeholders to address potential impacts, issues raised, and compensations according to regulations. According to the survey, the cumulative negative effect of acquiring 64.321 kanals of land will impact around 18 landowners. Only 0.14% and 0.11% of the land in the villages of Kuz Kana and Ranial, respectively, needs to be acquired compared to the proposed area with the complete community. The affected individuals and communities received complete compensation for their losses following the Land Acquisition Act (1984), KPK practice, and ADB policy on "Involuntary Resettlement." The study concluded that the project has no adverse environmental effects, and the minor potential impacts and compensation were done smoothly per the regulations. The lack of meaningful involvement by the public in the dam construction process is a key critique, which is especially essential for local communities directly impacted by hydropower projects. The study recommended implementing the environmental impact assessment for all hydropower projects in Pakistan.

Key Words: Environmental Impact Assessment (EIA), Karora, hydropower, area of influence, flora and fauna.

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1. INTRODUCTION

Pakistan has the sixth largest population in the world and is one of the developing countries with abundant potential for renewable energy resources [1]. It spans more than 1600 km from the southwest to the northeast [2]. Most of Pakistan's estimated hydroelectric potential is more than 40,000 MW and is in the territory of Khyber Pakhtunkhwa. Unfortunately, a large percentage of this untapped hydroelectric potential is still unused. Presently, there is roughly 10127 MW of installed hydropower capacity in Pakistan, of which 5790 MW is in the territory of Khyber Pakhtunkhwa, 2386 MW is in the province of Azad Jammu and Kashmir (AJK), 1802 MW is in the province of Punjab, and 151 MW is in Gilgit Baltistan province. Similarly, other hydropower projects with a combined estimated power generation of 8518 MW are now being built nationwide [3].

Over 16% of the world's total electricity consumption is met by hydropower, which also generates 71% of all renewable energy [4]. Many nations have increased their renewable energy portfolios, including considerable expenditures in massive hydropower development, to meet global carbon reduction goals [5]. Current hydroelectric projects might boost the world's hydropower capacity by 73%, with some estimates going as high as 100%. Hydropower development has local to regional environmental consequences, such as changes to river ecosystems, even while it offers a flexible renewable energy resource to supplement variable sources of electricity such as solar and wind [6]. Although the state's economy benefits from expanding hydropower capabilities, it also causes environmental harm and disputes over the reallocation of land and water resources [7]; [8]. Lack of meaningful involvement by the public in the dam construction process is a key critique [9], which is especially essential for local communities that are directly impacted by hydropower projects [10]; [11]. Countries have various policies to assess the environmental effects of hydropower development, operation, and mitigation measures. A requirement for an environmental impact evaluation (EIA), though with different processes in different nations, is one thing all regulations have in common [12]. Authorities may find it difficult to ensure whether EIA processes can keep up with the pace of development in areas where hydropower development is most dynamic and rapid or implemented at all in certain circumstances.

Although hydropower offers a versatile renewable energy source to supplement fluctuating energy sources (such as solar and wind), [13]; [14] hydropower production has regional and local environmental consequences, such as changes to river ecosystems [15]; [16]. Due to its unique characteristics and commitment to sustainability, hydropower has emerged as a significant force in the fight against the world's energy problems. Recognizing underlying resource finiteness and depletion [17], it represents a chance to meet ongoing energy demands brought on by economic and population growth while also maintaining environmental standards (especially in light of greenhouse gas (GHG) releases, global warming, and climate change concerns) [18] and simultaneously enhancing social well-being by supplying power to underdeveloped and remote regions [19]. Many nations have increased their renewable energy portfolios, [20] including considerable investments in the building of massive hydropower to achieve global carbon reduction goals [21]; [22].

Pakistan's Environmental Protection Ordinance (PEPO) 1983 established EIA as a mandate. The Pakistan Environmental Protection Act of 1997 (PEPA'97), which took the role of PEPO in 1997, increased the legal requirement for EIA and created the IEE / EIA Review Rules of 2000. Several regulations have also been produced to aid in the execution of the EIA system throughout the nation [23]. EIA Guidelines from 1986, EIA Energy Sector Directions from 1992, EIA Policies for Oil and Gas Investigating in Environmentally sensitive regions from 1997, Sub-sectoral Guidelines from Khyber Pakhtunkhwa EPA for 22 sectors, and Sub-sectoral Guidelines from Balochistan EPA for 3 sectors are a few of the notable guidelines. EIA has been elevated by landmark projects like the extraction of natural gas and oil in Kirthar National Park, but they have also shown that there is still much of a need to improve the approach in Pakistan [24].

Looking at the vast amount of EIA literature currently available, it is clear that many diverse contributions have been made to evaluate the effectiveness of national EIA systems [25]; [26]. The US, Canada, and the EU have all produced well-known comparative and [27]; [28]; transnational research [29]; [30], Others have focused on the quality of EIA reports' technical and scientific content. Numerous scholars worldwide have highlighted the importance of environmental impact assessments for small and large-scale hydropower projects. [31] demonstrated that benefit transfer shouldn't be used because each hydropower plant has unique and different impacts. This was demonstrated through the evaluation of assessment studies on the environmental effects of hydropower and the analysis of the various environmental impacts linked to hydroelectric power for particular cases. Their research highlighted the value of using a case study technique to establish priorities for alternative hydropower-producing facilities. Finally, they showed that being pertinent for policy design, choice trials were particularly well adapted for valuing the discovered environmental impacts.

The combined environmental effects of 27 small hydropower facilities and three major hydropower projects were investigated by [32]. The findings hinted at a precarious tendency that large-scale hydropower projects have fewer adverse effects than numerous small-scale ones. Still, they are inconclusive due to hazy data and a weak methodological foundation. They concluded that it was reasonable to assume that some large hydroelectric power developments would generate electricity at a lower cost to the environment than many small projects, which must be considered when achieving the government's renewable energy goals. Other advantages, such as the availability of regulated power, were also considered. For the small hydropower (SHP) plant's environmental impact assessment, [33] determined how an SHP plant in Spiské Bystré, Slovakia, affected the environment. The alternatives to a particular hydraulic structure were also evaluated quantitatively from the standpoint of the impacts' nature, importance, and duration. The work's conclusion suggested measures to lessen the negative effects and included the choice of the best alternative for the evaluated construction. The study's advantage was in emphasizing how crucial it is to evaluate the environmental effects of construction during the planning stage. The researchers concluded that it is much more difficult to eliminate the harmful effects of construction on the environment than to put preventive measures into place, so it is crucial to consider this when planning any proposed activities.

The preliminary and coarse assessment of the most pertinent effects of hydropower on fundamental elements of the river ecosystem were identified by [34] using river function indicators, a weight of evidence approach (and toolkit) was developed. Users can determine which environmental indicators may be impacted by hydropower development and which indicators have the highest levels of uncertainty and need additional research using a science-based questionnaire and predictive model. Visualizing inter-dependent indicator relationships provided by an assessment tool also aids in formulating hypotheses about the causal relationships examined by environmental studies. These tools were used by the researchers to analyze four real hydropower projects and one fictitious new hydropower project with various sizes and environmental contexts. They noted similarities between the results of our tools and the licensing procedure of the Federal Energy Regulatory Commission, which includes EIAs, as well as significant differences resulting from comprehensive scientific evaluations (our toolkit) versus regulatory policies. The tools discussed here were designed to make EIA processes more effective while maintaining the rigor and transparency of reasoning required for comprehending, considering, and mitigating the environmental effects of hydropower.

The structural shortcomings of environmental assessment for hydropower development were investigated by [35] in Himachal Pradesh, India. Based on a qualitative methodology involving document reviews, field observations, and interviews with environmental experts, the study contends that limiting EIAs to the project level ignores the more significant effects of extensive hydropower development. Therefore, the potential for the Strategic Environmental Assessment (SEA) concept to address current issues was critically discussed. [36] summarized the findings of a one-year study that sought to evaluate the caliber of EIA studies completed for Portuguese small hydropower plants. A thorough analysis of every EIA Report that served as the foundation for successful EIA processes involving this type of small-scale project was conducted under the previous two decades' worth of national EIA legislation. These projects, which are frequently hidden from view by the public and the media and are situated in remote regions upstream of secondary rivers, are likely to have a significant negative impact on the environment, especially on the aesthetic value and character of nearby landscapes and on pristine ecological habitats. And yet, they are frequently regarded as green initiatives created to generate energy without emissions. The literature review on comparable research projects completed in other countries helped shape the design of the evaluation criteria. The evaluation exercise exposed several technical and methodological flaws in a sizable portion of the cases [23]; [36]. Most of Portugal's EIA practices' strengths and weaknesses share characteristics with those seen in other national EIA systems within the EU. After all, converging results are expected from two EIA Directives over 20 years. The significance and scope of the particular issues identified as well as the advantages of the chosen solutions, however, do differ.

By conducting semi-structured interviews with local respondents, researchers evaluated how the four SHPs in India's Western Ghats were perceived to have affected socio-ecological conditions [37]. Respondent perceptions were then contrasted with the anticipated baseline of assured impacts after the primary interview data had been sequentially validated with secondary data. We assessed the degree of knowledge about SHPs, perceived socioeconomic effects, influence on resource access, and effects on interactions between people and elephants. SHPs were not well known to the general public, and promises of generating local electricity and jobs remained largely unfulfilled. The majority of respondents also experienced numerous unanticipated negative effects. We discovered a direct correlation between the development of SHPs and rising levels of conflict between humans and elephants. We recommend that policies about SHPs be appropriately revised in light of the discrepancy between assured and actual social impacts. In another study, [38] planned to use the hydroelectric plant environmental impact assessments (EIA) from 1990 to 1997 in Trentino, Italy. His research aimed to create an analysis that, starting with the unique characteristics of environmental projects, locations, and EIA studies, detects similarities in data structures using a particular index and multivariate statistical methods. RFS standards were examined by [39] for their primary environmental effects while accounting for the various water uses particular to each dam site. Natural variations in river flows create a range of habitats and maintain the diversity and complexity of biological groups. As a result, the current study has important ecological, social, and economic ramifications because a sound evaluation of the RFS requirements guards against potential instability in biological communities and potential loss of biodiversity. Thus, the study aimed to overview the Environmental Impact Assessment and mitigation measures for the Karora hydropower project to highlight the gap between institutional framework and actual implementation and practices.

2. METHODOLOGY

2.1 Study Area

In the Shangla District, as shown in Figure 1, the village of Kuz Kana is located about 300 meters upstream of the run-of-river project known as Karora HPP.

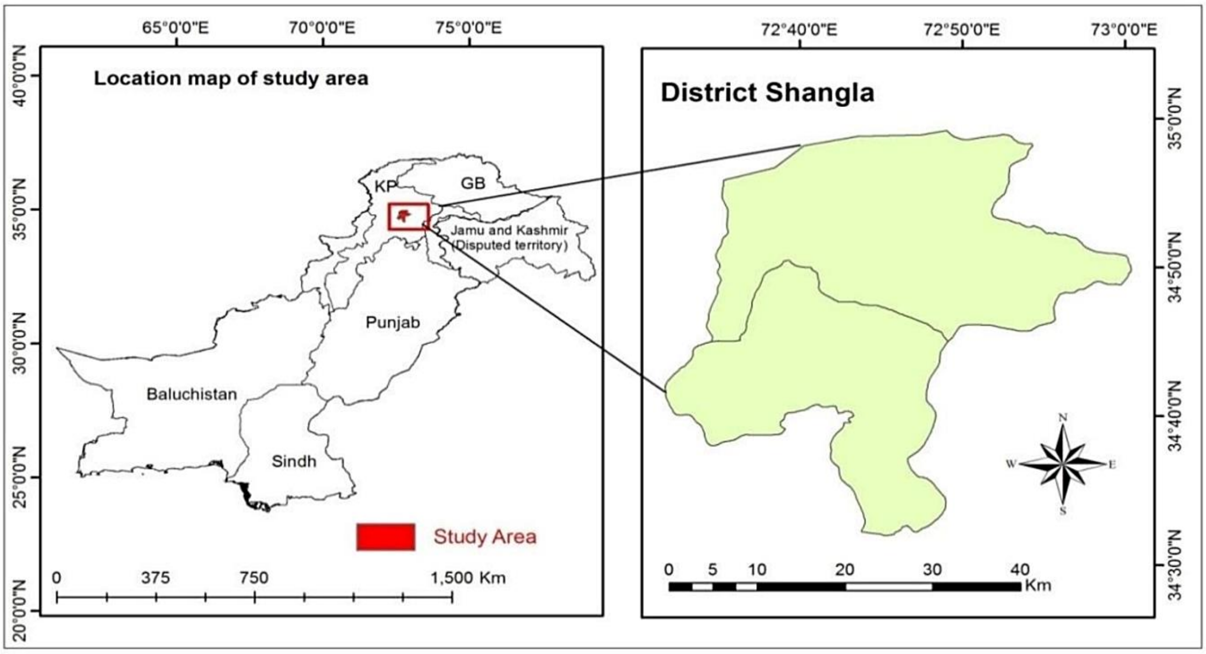

Figure 1 Location map of the study area highlighting Shangla district [40].

Nearly 25 km separate the project from Besham, located about 225 km from Islamabad. The powerhouse is situated 5.2 km downstream of the proposed weir site, close to Ranial village, while the proposed weir site is situated at longitude 72° 45' 25" East and latitude 34° 55' 21" North. Access to the Karora HPP is provided by the Besham-Mingora Road, which is in fair condition up until Karora Village, and the single metaled road, which is in fair condition from Karora Village to Kuz Kana Village near the weir site. The Karora HPP has an 11.8 MW capacity for power production [3]. The Khyber Pakhtunkhwa government is funding the project with 90% coming from Hydel Development Fund/Foreign Investment and 10% coming from provincial ADP. The project increased the national grid's available electricity by 11.80 MW [41].

2.2 Adopted Procedure

The current study focused on the Review of Environmental Impact Assessment and mitigation measures for the Karora hydropower project, Shangla, Pakistan. Considering the stepwise methodology as shown in Figure 2, the authors reviewed the area of influence, the land resources, water resources, flora and fauna, the Socio-Economic Setup of the District Shangla, consultations with the stakeholders, focusing on the potential impacts and issues raised by stakeholders and their compensations as per the regulations.

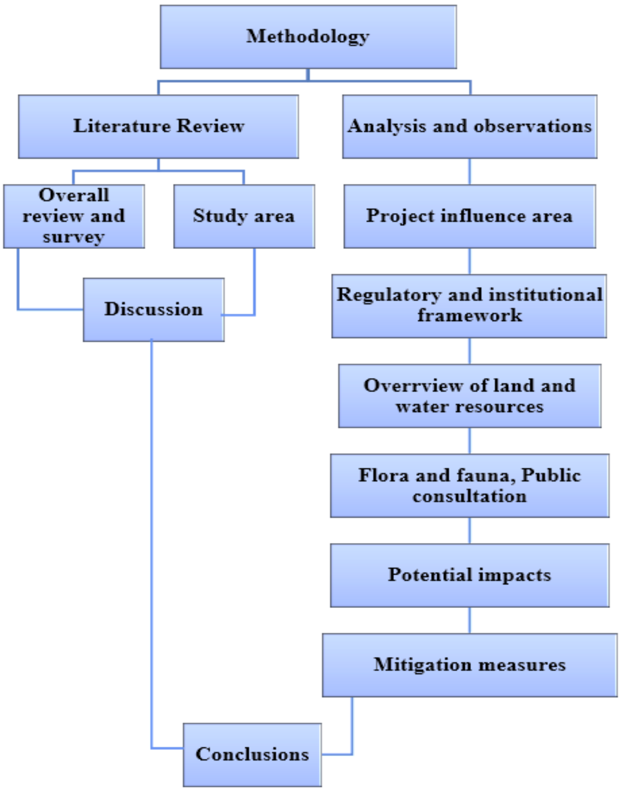

Figure 2 Flowchart to explain the adopted methodology.

2.3 Area of influence

The river was diverted into the Power Tunnel for practical purposes of power generation for about 9 km of the river reach from the Weir up to the Powerhouse during the low-flow season as shown in Figure 3 and 4. The areas that were excavated for the power tunnel are on high benches. These areas won't be directly impacted, but the vibrations from drilling and blasting the Power Tunnel may disturb the settlements on these benches. Most of the residential area won't be directly impacted by the project, but mixed types of indirect effects are likely to occur. Heavy machinery and vehicles must first be introduced to transport construction materials from quarries on the town's other side. On the other hand, hiring outside labor could help the local economy by boosting local sales [42].

Figure 1 Location of Weir site and powerhouse (Courtesy: Google Earth).

Figure 2 Tunnel construction at Karora [43].

2.4 Land Resources

At the location of the weir, the banks of the river Khan Khwar are nearly totally covered with a thick alluvial layer that includes terrace farming, clusters of trees, and self-grown grass and vegetation. The geological circumstances identified for building an open channel weren't found to be favorable, so a cut-and-cover concrete procedure had to be adopted. Favorable geological conditions can be found at Penstock, Fore Bay, along with Power House [42]. It is sensitive from a seismic perspective. According to a study by [3] The Karora hydropower location/site is situated in a seismically active region that is susceptible to earthquakes of extremely high magnitude. Based on felt intensity data in addition to the instrumental record of both micro and macro seismicity, the Major Boundary Thrust (MBT), Main Mantle Thrust (MMT), Kashmir Thrust (KT), as well as Indus Kohistan Seismic Zone (IKSZ) faults have been determined to be active in the Project region.

2.5 Water Resources

Khan Khwar River is the primary surface water resource in the project area. It is an Indus River tributary. The development will use the water from Khan Khwar, which emerges from the district's northern region. Khan Khwar's total catchment area is approximately 230 km2 at the project weir site. At the powerhouse area, the average monthly flow was 2.03 m^3/s in January 2003 and reached a maximum of 20.2 m^3/s in April [42]. The Karora Hydropower Project is not located close to any protected areas. National parks, wildlife refuges, playgrounds, wildlife parks, and army areas are only a few examples of protected areas. In the area of the Karora Hydropower Project, there are no endangered or unusual species.

2.6 Climatic scenarios

According to the data, the mean monthly temperature ranges from 8 °C in January to 28 °C in June. The region receives 60.9 mm of precipitation on average per year. There is, however, a significant seasonal variance. August experiences the most precipitation, with an average of around 100.5 mm. With an average of 14.3 mm, November is the month with the least amount of precipitation [44] as shown in Figure 5. Under normal circumstances, the project region's air quality and surroundings are typically clean and fresh. Due to the absence of significant industrial or vehicle activity nearby, no significant sources of air pollution exist. The project location is concealed in a valley surrounded by steep, vegetated slopes. There aren't many houses close to the locations of project components.

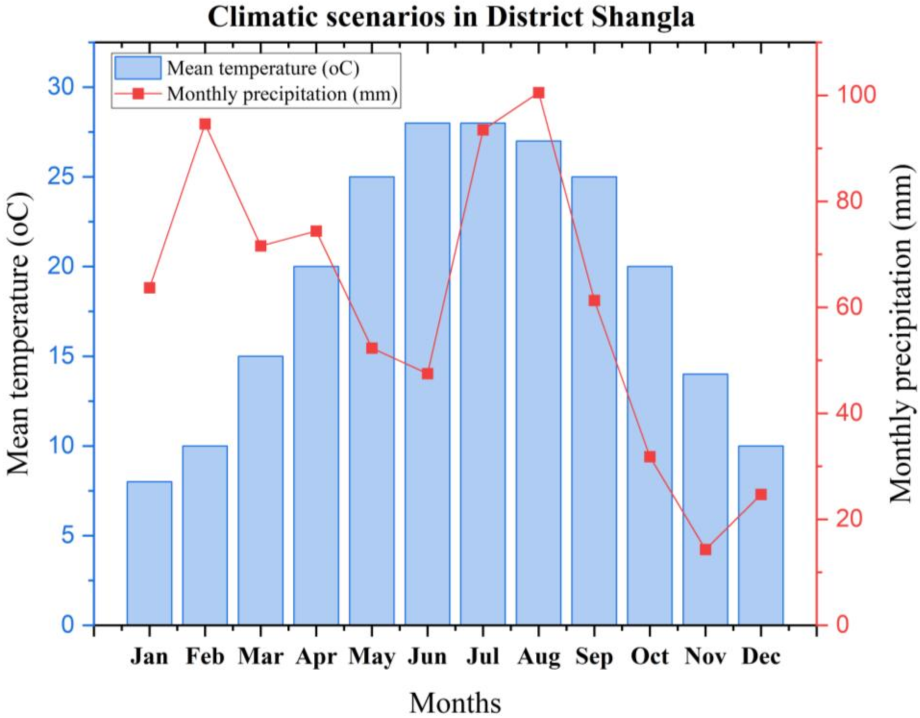

Figure 3 Climatic scenarios in District Shangla expressing the monthly precipitation and mean monthly temperature.

The project area's ambient noise level is below the allowed limit of 85 dB [42]. Regarding demography, the district's population is growing at an average yearly rate of 3.3 percent. There are 64,391 total households, with a normal household size of 8.1 people [45]. Regarding Flora, the area is abundant in uncultivated plants. In addition to the sparse vegetation that covers practically the entire area, the mountains are covered in wide leaf & pine tree forests that vary in density depending on height. Usually, the farming villages' courtyards have fruit trees. The majority of the project area's wildlife is local. But throughout the winter, a few migrating bird species stop by the project area on their way south. No notable reptiles have been observed from the project region because of the harsh winters and short, relatively favorable summers.

2.7 Socio-Economic System of District Shangla

The region's primary economic sectors are agriculture, cattle, and services. Rice, maize, and wheat are all grown. Springs having good quality provide drinking water. no network for sewage. A total of 50.79% of the landholdings in the project area are arable, 23.62% is forest land, and 25.59% is wasteland or exists in the form of an unusable wasteland. 18 families, 12 from the village of Kuz Kana and 6 from Ranial, were affected. Only one of these households will lose both their land and their home; the other seventeen households will lose uncultivated or other sorts of land [42]. The respondents' most urgent concerns are the absence of health facilities, educational possibilities, and a bridge crossing over the project area's rivers and tributaries. They desired that the Project would improve the area's services and, ultimately, the community's living standards by bringing educational, physical infrastructure, health, and other services there. According to the results of a field investigation analysis on the availability of social amenities and infrastructure for households, mosques, cemeteries, electricity, and secondary and primary educational institutions for boys and girls are the facilities that are accessible to either all or a significant portion of houses.

2.8 Public Consultation

The objectives of public consultation are to share information with stakeholders on the proposed project, understand stakeholders, understand the concerns of the female members, and address specific issues related to the disruption of settlements, graveyards, and earnings of people who get benefits from the river, etc.

The general Concerns of the Stakeholders were:

- The contractor must obtain the community's consent before using local resources.
- Contractor laborers need to be mindful of regional traditions.
- Contractors must dispose of their camp waste appropriately and not leave it in public spaces.
- Local women's freedom of movement shouldn't be restricted by building activity.

Diversion of water to the power tunnel could cause water scarcity in the surrounding population. Arrangements should be made to limit noise and air pollution. The project should regularly offer job opportunities to the local community.

Address of Stakeholders' Concerns was done by doing the following actions:

- The local population will be given preference for employment throughout construction activities.
- The waste from the building camp will be properly disposed of.
- Appropriate working hours will be used to reduce the complication.
- Jobs will be made available to the local population.
- The Project will take the necessary steps to reduce noise and air pollution. The release of water from the weir may be made mandatory depending on social or aquatic ecological considerations.

The owners of these power plants and water mills should receive a proper compensation package, and the project's promoter is responsible for disposing of excavated waste properly because it will affect agricultural land. Jobs are also announced for the affected parties and the union council. According to the Resolution of Grievances and Demands, no micro hydel generators or water mills will be affected by the project, as was seen during a reconnaissance survey of the project area, and affected locals will be given jobs based on their qualifications and skill sets. An MOU was created between locals and customers to serve as a record of resolving the issues brought up by the locals with assistance from regional district government representatives.

2.9 Social Mitigation

Numerous laws in Pakistan grant and safeguard proprietary rights. The most often used legal framework for acquiring land alongside other assets for development initiatives is the Land Acquisition Act of 1894 (LAA). A thorough Resettlement Action Plan (RP) for every aspect or subproject will be created in agreement with the established resettlement policy if the project's impact results in the displacement of more than 200 individuals (40–50 families). An "Abbreviated Resettlement Plan" rather than a "Comprehensive Resettlement Plan" may be sufficient if the project's impact is negligible or modest and less than 200 people (40–50 households) are affected and/or displaced. This ARP is created to address the project's minor effects. It offers an analysis of the effects, defines the kinds of losses that will occur and their nature, and creates an entitlement matrix that will serve as a guide for allocating compensation and relocation benefits.

3. RESULTS

3.1 Potential Impacts

According to the survey during EIA, the cumulative negative effects linked to the acquisition of 64.321 kanals of land will impact around 18 title holders/Aps who are the land's owners. Only 0.14% and 0.11% of the land in the villages of Kuz Kana and Ranial, respectively, needs to be acquired compared to the proposed area with the complete community.

The affected individuals and communities would get complete compensation for their respective losses following the Land Acquisition Act (1984), KPK practice, and ADB policy on "Involuntary Resettlement". The following compensation criteria were adopted:

a. The land-for-land option should ideally be chosen.
b. If not, proprietors (including women) must receive cash compensation for the land based on current market /replacement value + 15% Compulsory Acquisition Surcharge (CAS).
c. c. To calculate compensation for the removal of fruit trees, the worth of fruit for the next 10 years, estimated at current market values, is utilized.

d. The project will disrupt one house inside the power channel region. Seven people live in the disrupted house, with a total covered area of approximately 6 Marla (1,748 ft2). The loss of a residential structure will be paid based on the replacement cost.

The attainment of property for a weir, an access road, or the construction of contractor facilities will undoubtedly alter the local land use patterns regarding land productivity and use. Restoration of temporarily seized areas may give rise to disputes with landowners. Inland sliding and erosion and soil erosion will impact the local community's agricultural terraces. If uncontrolled blasting is done in quarry regions, soil erosion may also happen. The soil's ability to bind water will decrease as the vegetation cover grows less. The view of vegetation and plants at the powerhouse and weir site is shown in Figures 6 and 7, respectively. For soil contamination, chemicals, including fuels, solvents, oils, paints, other building materials, and concrete, may leak and contaminate the land. Future land uses may be hampered by potential soil pollution caused by chemicals and petroleum products at campsites, workshop locations, and equipment washing yards.

Figure 4 View of vegetation at powerhouse Site. (Source: Tender documents)

Figure 5 View of vegetation at Weir site. (Source: Tender documents)

Local water resources, primarily provided by springs, could be negatively impacted by the project's implementation in terms of quantity and quality. Resources for subsurface and surface water may get contaminated by fuel and chemical spills in the project area. If blasting is not managed, soil erosion could contaminate surface water resources. Dust Skin and respiratory conditions may be brought on by smoke, other pollutant emissions, and dust. The passage of big vehicles hauling plants and other materials through the area will impact the roads and traffic. Numerous large and tiny fires in the work camp may cause smoke and pollution, which can obstruct visibility, hinder traffic, and lead to suffocation in addition to spreading respiratory tract disorders. Dust and pollution will be produced during excavation activities. The site's air quality will also deteriorate due to emissions from plants used in earthwork activities. Cutting down trees can accelerate soil erosion, which will harm flora. Dust-film-forming dirty air will cover leaves during construction, obstructing sunlight and stomata. Exploration and blasting will harm the local fauna, particularly the animals and reptiles. Uncontrolled blasting could harm the project area's native animals. Birds will typically flee the project to find shelter and food elsewhere. The general mobility of the locals and their livestock within and adjacent to the project region will likely be hampered regarding the impacts on local communities and the workforce. The community will have to deal with noise and dust problems during construction. The flow of traffic will be hampered. In terms of gender issues, the introduction of foreign workers may result in problems due to their ignorance of regional customs and conventions. Additionally, it will restrict local women's ability to move about while working in the fields, tending to livestock, gathering fuelwood, etc. The project's relocation of private houses and public infrastructure will disrupt one residential unit along a power channel. This home's total covered area is around 6 m^2 (1,748 ft^2). There are no known historical or archaeological sites near the project area. Heavy flooding and seismic activity are two potential natural forces that could affect the project's thorough design phase. Figure 8 elaborates on the contour map, highlighting the riverbed, project area, existing buildings, influenced area, camps & colony areas, and sand trap in the study area.

3.2 Mitigations of potential impacts

According to the documentation study, before beginning construction, the contractor will submit a location plan and layout of the facilities for review and approval to the Local Government and KPK-EPA to mitigate the potential consequences outlined above. Wasteland, or regions not used for agriculture, housing, or forestry, will be used whenever possible to build project facilities and store borrowed materials. According to the local community's desire, a protection dike is suggested to prevent soil erosion and land sliding. Retaining walls will be installed to protect the road embankments from erosion and gravity-induced slippage. To prevent erosion on gentle valley side slopes, vegetation will be planted. The contractor will have to teach its employees about the handling and storage of goods as well as create a training manual to prevent soil contamination. By dumping all containers into lined pits or caissons, soil pollution will be reduced. The contractor oversees limiting water waste when doing construction work and setting up camp and will seek permission from the local authorities before using local water supplies. Camps will be built at least 500 meters from the closest local village to prevent contamination of groundwater and surface water resources held by the local community. The retaining walls will be constructed out of excavated rocks. All used machinery, cars, tools, and generators shall be maintained in good operating order. Use and offer clean, smoke-free fuel in the labor camp to prevent smoke from burning firewood or trash. It is forbidden to cut down and burn trees or plants for fuel. Earthwork activities should not have an adverse impact on the air quality; hence, water should be sprayed frequently to reduce dust pollution. Water should be sprayed regularly. All used cars, machinery, equipment, and generators will be maintained in good operating order.

Air quality should be checked close to the factory to prevent dust, smoke, and other pollutants from equipment and plants. Water should be sprayed regularly. It is estimated that against cutting of about 204 trees SHYDO will provide compensatory plantation at the ratio of 1:3. As such, the total compensatory plantation comes to about 612 trees more ever to minimize the impacts on flora. The weir intake structure will be designed and constructed to allow the minimum mean monthly 0.918 m3/s of water flow to always be maintained in the river for the maintenance of riparian as well as aquatic ecosystem of downstream. Staff and personnel from the Contractor will be under strict instructions not to harm any vegetation to protect Flora. Cutting any mother trees will not be done. Hunting, poaching, and pestering wild animals will all be strictly restricted to protect the fauna. There will be no nighttime blasting or other loud noise-making activities. avoiding noise-making activities when breeding is most important. not to kill, entrap, or shoot any birds.

The contractor will ensure that the mobility of the residents, notably women and children, along with their livestock, is not impeded by the construction operations to avoid impacts on local populations and the workforce. Blasting will take place during the predetermined times. Camps will be placed at least 500 meters from the closest local town to prevent contaminating privately held water resources. There will be local merchants available. To prevent gender issues, the contractor will take good care of the neighborhood and promote cultural sensitivity. The contractor will strongly advise the staff to avoid engaging in unethical behavior. Privacy should not be compromised by construction activities, especially for women. Private homes and public infrastructure moving expenses will be covered on a replacement cost basis. For religious, cultural, and historical sites, there is no need to relocate religious structures. Therefore, no mitigation is necessary other than the contractor's adherence to prayer timing, especially on Fridays. The Karora HPP has a storage capacity of approximately 22,521 m^3 and a weir height of around 5 m. It belongs to the tiny Category as a result. Since no people would be at risk if the dam failed and the flood reached that area, the US Army Corps of Engineers determined that the weir's Hazard rating would be "Low". Complying with the safety precautions for construction workers as per International Labor Organization (ILO) Convention No. 62, as far as applicable to the project contract.

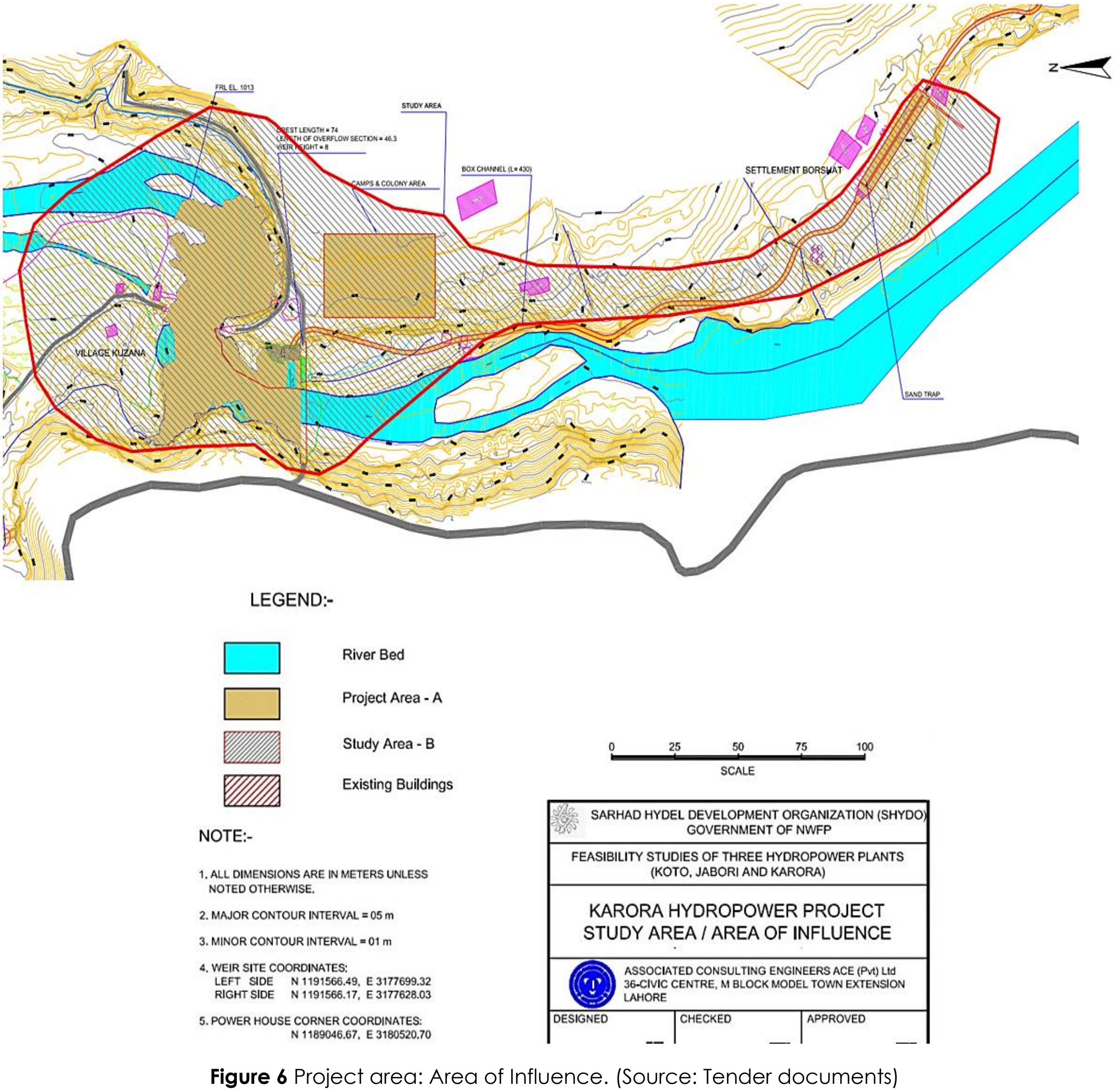

Figure 6 Project area: Area of Influence. (Source: Tender documents)

Table 1 below shows the environmental cost of resettlement decided to provide to the affected individuals in the project area before and after the 2010 flood.

Table 1 *Environmental cost of resettlement as per rules.* [42]

Estimated Environmental Cost in Pre & Post Flood Conditions									
Item No.	Item	Category	Unit	Before Flood			After Flood		
				Average rate (Rs.)/unit	Quantity	Estimated Amount (Rs.)	Average rate (Rs.)/unit	Quantity	Estimated Amount (Rs.)
Estimated Cost of Resettlement									
1	Permanent Land Acquisition*	Agricultural Land	Kanal	300,000	28	8,400,000	300,000	24	7,200,000
		Waste Land	Kanal	100,000	14	1,400,000	100,000	22	2,200,000
		Forest/ Grazing Land	Kanal	200,000	6	1,200,000	200,000	2	400,000
3	Temporary land Acquisition**	Agricultural Land	kanal	50,000	16	800,000	50,000	16	800,000
4	Structure***	Residential Unit	ft^2	500	1748	874,000	925	1748	1,616,900
5	Bridge	At Kuz Kana	Cost included in the weir	-		0	0		0
		At settlement Mareen, village Ranial	A concrete bridge will be built in order to access traffic to power house site.	cost already include in Cost Estimation Chapter		0	cost already include in Cost Estimation Chapter		0
					Total	12,674,000			12,216,900

4. DISCUSSION

Karora hydropower project utilize the water resources of the Khan Khwar river for power generation. It comprises of four main components, viz., weir, intake structure, power tunnel, power channel, sand trap and powerhouse. The weir is located near Kuz Kana Village on the Khan Khwar river. The powerhouse and outlet portal of the power tunnel is located at settlement Mareen, village Ranial about 9 km downstream of the weir structure. Riverbed elevation is 1005 masl and weir crust elevation is 1020.6 masl, so dam height is 8 m. The maximum operating reservoir elevation is 1011 masl. Reservoir capacity (at Elev. 1013) is 22,521 m^3. Tunnel length is 2,960 m long and power channel length is 430 m. The Karora Hydropower Project's feasibility study was finished in August 2011; later, construction began in December 2014. A surge shaft with an 8-meter diameter and a penstock with a length of 408 m are both installed at the tunnel's terminus. The inlet valves of each (of the two) Horizontal Francis turbines, each having an installed capacity of 6.24MW (Q=4.875 m3/sec, Head=142m), are connected to a generator with a 6.94MVA capacity at the end of the penstock. The plant factor is 69.06%, and the annual energy is 71.39 Gwh. The power will be disconnected at Besham Qilla after being evacuated via a 132KV-10 Km transmission line. The project will increase the national grid's available electricity by 11.80 MW [41]. The authors looked at the region of influence, the land resources, the water resources, the flora and fauna, the socio-economic structure of the Shangla District, and consultations with the stakeholders, paying particular attention to any potential effects and concerns mentioned by the stakeholders and their compensations following the law. The project has not negatively influenced the environment, and the potential damages and compensation were handled efficiently and in accordance with the law, according to the authors' observations.

The study was supported by some recent research conducted in this field. A recent study by [46] also strengthened the observations of the current study in which the researchers investigated the structural limits of Environmental Impact Assessment (EIA) guidelines for hydropower development in Pakistan. Their study included the document review of the EIA reports about hydropower projects in Pakistan, scientific questionnaires from decision-makers, and public consultation z. The document evaluates that an adequate mechanism is available, and donors like the Asian Development Bank and World Bank observe the implementation process of EIA in Pakistan. However, a comprehensive analysis of the EIA system found several things that could be improved, not only in the institutional framework but also in actual implementation and practices. In another study by [47], the researchers investigated the post-construction assessments of EIA guidelines. They concluded that environmental impact differences between actual and predicted results could be used to testify to the rightness of the EIA predicted results and the reasonability of environment protection design. The study by [48] also revealed that despite a sound legal basis and comprehensive guidelines, evidence suggests that EIA has not yet evolved satisfactorily in Pakistan. An evaluation of the EIA system against systematic evaluation criteria, based on interviews with EIA approval authorities, consulting firms, and experts, reveals various shortcomings of the EIA system. These include the inadequate capacity of EIA approval authorities, deficiencies in screening and scoping, poor EIA quality, inadequate public participation, and weak monitoring. In another study by [49], While assessing the EIA process at the Gulpur Hydropower project, Kotli, AJK, it was concluded that the project had had no adverse environmental impact and that potential impacts and compensation were handled effectively and legally.

5. CONCLUSIONS:

According to the study's recommendation, all hydroelectric projects in Pakistan should conduct an environmental impact assessment. The statement emphasizes the adherence to the EIA Guidelines in Pakistan for determining the worth of ecological resources, describing the proposed development's effects, evaluating the effects' importance, and assessing any remaining consequences. Special attention was given to potential effects and concerns the stakeholders raised and their legal compensations. Developed countries frequently update their EIA guidelines to address emerging challenges effectively. Upon reviewing the literature, it was noted that in Pakistan, there is a need for a well-established system to embrace changes and ensure that guidelines are regularly updated with the passage of time. An exhaustive examination of the EIA system reveals various aspects that can be further enhanced, encompassing the organizational structure, execution, and tangible procedures. Furthermore, it is recommended that the EIA guidelines must be aligned with the internationally recognized guidelines implemented in developed nations. Additionally, decision-makers must undergo thorough training and possess up-to-date knowledge to adapt effectively to the present era's progress. The study is limited to analyzing the environmental impact assessment and mitigation measures following the EIA guidelines in the Karora hydropower project. It used the data provided by the Pakhtunkhwa Energy Development Organization and the official documents for the EIA by the National Electric Power Regulatory Authority.

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Authors' Contributions:

Asim Qayyum Butt: Conceptualization, Methodology, Visualization, Investigation, Writing- Original draft, Writing-Reviewing and Editing. **Donghui Shangguan**: Conceptualization, Supervision, Project Administration, Funding Acquisition. **Faizan Khalid Butt:** Methodology, Writing- Reviewing and Editing. **Amjad Ali Khan**: Writing-Original draft, Writing- Reviewing and Editing. **Muhammad Afzal**: Investigation, Writing- Reviewing and Editing. All authors have read and approved the manuscript.

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