International Journal of Environment, Agriculture and Biotechnology
Vol-9, Issue-1; Jan-Feb, 2024
Peer-Reviewed International Journal
Journal Home Page Available: https://ijeab.com/
Journal DOI: 10.22161/ijeab

A Cost-Benefit Analysis of Building a Dam in Pakistan: To Mitigate Floods, Promote Tourism, Boost Agriculture, and Generate Electricity

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Received: 20 Jul 2023; Received in revised form: 29 Nov 2023; Accepted: 05 Jan 2023; Available online: 16 Jan 2024

Abstract— *Every year, Pakistan is on the verge of a serious water crisis. It is expected that the crisis of water shortages in Pakistan will reach an alarming level in the near future. Water degradation, climate change, particularly recent global warming, overuse, misuse, diminishing water availability, a lack of water management policies, pollution, population growth, and environmental neglect have all contributed to this crisis. This has undermined Pakistan's economy. Floods in Pakistan have adversely affected livestock, infrastructure, lives, and property, as well as agricultural land and crops. Floods negatively impact agricultural production and the country's economy without adequate water management. The travel and tourism sector in Pakistan plays a crucial role in the country's economy and contributes to its growth and development. However, despite its potential, this sector remains unsatisfied and faces several challenges and limitations. Furthermore, Pakistan faces a persistent electricity shortfall that has led to the implementation of load shedding across the country. The shortage in electricity supply has become a significant issue for both businesses and consumers, impacting the economy and overall quality of life. This paper examines the cost-benefit analysis of building a dam to reduce flood damage, promote tourism, and boost agriculture and electricity. It is difficult to provide accurate estimates of dam construction costs due to a lack of precise information. So many assumptions have been made to complete the analysis. There will also be a sensitivity analysis to test some assumptions.*

Keywords— ***Cost-benefit analysis, Dam construction, Analyze assumptions, Floods impact agriculture, Reduce flood damages.***

I. METHOD

The construction of dams is a complex and costly endeavor that requires meticulous planning and careful consideration of various factors such as location, design, materials, and environmental factors. However, accurately estimating dam construction costs poses a significant challenge due to the inherent uncertainties and complexities involved. In order to gather the necessary information, this paper will utilize literature studies, secondary sources, case studies, research papers, surveys, and evaluations of challenges. By combining these methodologies, a comprehensive analysis will be conducted to develop reliable cost estimates, providing valuable insights for dam construction projects.

In addition to the sources mentioned above, this paper also relies on numerous assumptions and considerations in order to conduct a comprehensive analysis. One notable limitation is that the exact data on the construction costs of the dam was not available in the recommendation project. As a result, several assumptions have been made to complete the analysis and provide a balanced assessment. In order to ensure that the recommendations are as accurate as possible, a sensitivity analysis has been conducted to test a number of the assumptions. This analysis allows us to evaluate the impact of varying input values on the overall conclusions and recommendations.

Building dams has emerged as a crucial strategy for addressing various issues related to water resource

management, flood control, and hydroelectric power generation. This paper provides a comprehensive and actionable plan that takes into account the unique challenges and circumstances of the situation the country is facing and explores the potential benefits of building dams as well as provides recommendations and solutions for the government to excellently implement these programs.

II. INTRODUCTION

Pakistan faces many challenges that urgently require attention, including the severe electricity shortfall, the impact of climate change-induced floods on agriculture, the poor natural, cultural, and non-leisure resource ratings, and the deepest energy and economic crisis in its history. The country's development must address these issues head-on and work towards a more sustainable and resilient future.

Pakistan is currently facing a severe electricity shortfall, resulting in frequent power outages across the country. Even people in industrial areas face heavy electric load shedding for many hours a day. This persistent shortage of electricity not only hampers productivity but also disrupts daily life and hampers economic growth. The electricity shortage in Pakistan can be attributed to various factors, including inadequate infrastructure, energy theft, and inefficient energy production. The lack of investment in power generation and transmission infrastructure has further exacerbated the situation. Pakistan is currently facing a massive energy crisis, with a significant demand and supply shortfall of between 5000 and 8000MW. This power shortage has created severe consequences for the economy and the country as a whole. To address the urgent need for reliable and sustainable power, the government must develop a comprehensive initiative for the future (PEC et al., 2014). The government must take immediate action on several fronts in order to alleviate the energy crisis. As a first step, it is essential to invest in new power plants, upgrade existing ones, and build new dams in order to increase their efficiency and productivity.

The tourism industry in Pakistan is a substantial sector that holds significant importance for the country's economy. It not only provides employment opportunities but also contributes to the generation of foreign exchange revenues. However, despite its significance, this area of research has received relatively little attention in Pakistan. According to a study conducted by the World Forum Report 2019, Pakistan ranked among the lowest in terms of competitiveness for travel and tourism worldwide, especially in comparison to other South Asian countries. This low ranking indicates that Pakistan needs to prioritize the development of tourist points, eco-friendly destinations, and exploring opportunities in order to attract national and international tourists. The tourism sector has the potential to contribute significantly to Pakistan's economic growth. By attracting tourists from both within the country and abroad, Pakistan can generate foreign currency reserves, boost domestic tourism, and promote cultural exchanges. This, in turn, can lead to the development of infrastructure Pakistan's low ranking in the Travel and Tourism Competitiveness Index can be attributed to the lack of travel and tourism spots, such as ecofriendly environments and parks, fisher spots guesthouses, and hotels. By prioritizing the development of these areas, Pakistan can enhance its attractiveness as a tourist destination and attract a wider range of visitors (Altaf et al., 2021; World Economic Forum, 2019). In order to enhance the tourism sector, Pakistan should focus on developing attractive tourist points. Additionally, investing in hotels and resorts, as well as implementing efficient marketing strategies, can attract more tourists. Developing eco-friendly destinations such as dams is another crucial aspect of attracting tourists.

In rural areas, the agriculture sector is crucial to poverty alleviation, economic development, and food security. This sector contributes 19.2 percent to GDP and employs 38.5 percent. The country produces cotton fifth in the world. The country exports 60% of textiles and cotton products. Due to this, agriculture contributes 0.6 percent to GDP and 2.4 percent to value added (Finance Division, Government of Pakistan, 2022). The Finance Division, Government of Pakistan’s report emphasizes the importance of sustainable growth in the agriculture sector for food security and rural development in the country. The report highlights that water interests in Pakistan are often conflicting when it comes to water use in agriculture. It stresses the need to adopt water management techniques to ensure food security in the country (Finance Division, Government of Pakistan., 2022). Climate vulnerability poses significant challenges to Pakistan's agricultural sector, negatively affecting its economy. Investing in dams is crucial for addressing these challenges. Dams support irrigation, increase agricultural production, and contribute to sustainable development. By prioritizing sustainable development and implementing effective water management policies, Pakistan can enhance its resilience to climate-related risks and ensure the well-being of its people.

Pakistan is one of the countries in South Asia which experiences the most floods each year. Floods occur regularly in Pakistan, causing significant destruction and loss of life. These floods often result from heavy rainfall, melting of snow in mountainous regions, or the release of water from dams or reservoirs. The intensity and frequency of these floods have increased significantly in recent years, posing a significant threat to the country's infrastructure and development. The damage caused by floods is extensive. It

not only affects human lives but also disrupts economic activities, destroys infrastructure, and damages agricultural land. Pakistan has not been able to manage water efficiently so far and has not been able to build enough reservoirs and dams to meet the country's needs and protect the country from natural climate change floods (Ali, 2013; Akbar et al., 2021).

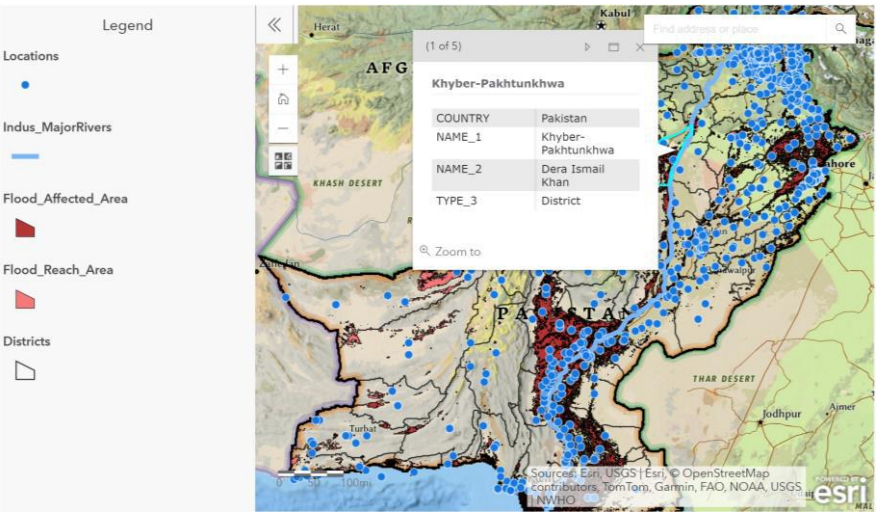
The paper aims to perform a cost-benefit analysis of building a new dam in Pakistan to mitigate floods, promote tourism, boost agriculture, and generate electricity. The cost-benefit analysis of dam construction is a complex and multifaceted exercise. It involves examining the potential benefits and costs associated with constructing a new dam in Pakistan. This analysis will provide insights into the economic feasibility and the potential benefits of dam construction. This analysis involves varying key assumptions and parameters to assess their impact on the project's economic viability. By examining the potential benefits and costs associated with constructing a new dam, we can determine whether it is economically beneficial compared to the status quo. Policymakers and development practitioners will gain valuable insight from this paper regarding the building of new dams in Pakistan.

III. LITERATURE REVIEW

The literature review has provided an overview of floods and their impacts, the causes of floods in Pakistan, the country's flood protection facilities, the institutional responsibility for managing floods, and the flood management options. The paper concludes by emphasizing the need for sensible water management and flood protection facilities in Pakistan, such as the construction of a dam. This dam would not only facilitate water management but also promote tourism, mitigate floods, and benefit agriculture. Additionally, a cost-benefit analysis will be conducted to assess the viability of constructing a big dam in Pakistan.

Pakistan's major floods and their impacts

Pakistan has been identified as one of the most climate-vulnerable countries in many United Nations and government reports. Sectors such as water, agriculture, and food are among them. There have been several major flood disasters hit Pakistan in the last decade, including those of 2003, 2010, 2011, 2012, 2013, and 2014. As a result of the scale and intensity of natural hazards, such as severe thunderstorms, floods, glacial melting, and droughts, all sectors of society are placed at risk (Ismail & Malik, 2020).



Shahzad Ismail's GIS Map Project 2023, Devastating Floods In Pakistan, published at https://newworldhope.org/environment.html

The GIS Map Project 2023 highlights the devastating impact of floods on the Indus River in Pakistan. The map provides valuable insights into the potential effects during and after floods when heavy rain hits the country. The Indus River flows for more than 1900 miles (3,060 kilometers) throughout Pakistan, making it the longest river in the country., traversing through Pakistan before reaching the southern province of Sindh and the Indus Delta, where it meets the Arabian Sea. The river plays a crucial role in Pakistan's environment, economy, and culture. However, due to the absence of a dam system, the Pakistani government struggles to effectively control and mitigate the damage caused by heavy rainfall. The maps provide a comprehensive view of the potential effects caused by floods, particularly with the Indus River. When heavy rain hits Pakistan, the Indus River becomes full, resulting in

extensive flooding in the surrounding areas. This flooding not only damages and destroys the populated areas and agricultural lands located near the river but also poses a significant risk to lives and economic stability. The GIS Map Project 2023 includes data that identifies and highlights the districts and areas in Pakistan that are most vulnerable to flooding. By identifying the high-risk areas, policymakers and disaster management agencies can allocate resources and efforts more efficiently to alleviate the impact of floods. Flash floods in rivers and streams in Pakistan have increased during the rainy season when heavy rains fall in hilly and semi-hilly areas. Over the years, the frequency and intensity of these floods have increased due to the increase of the population near the rivers (Ghumman et al., 2012).

In 2003, the Pakistan floods occurred due to monsoon rains and melting snow causing great damage to many areas of Sind, Khyber Pakhtunkhwa (KPK), and Baluchistan Provinces. 130 people lost their lives as a result of this flood and 4,476 villages were badly affected as a result (Yaqub & Eren, 2015).

As a result of heavy monsoon rains in Sindh province, the flood of 2011 affected many districts of this province severely. The Pakistan floods of 2011 caused a significant loss of crops in terms of both standing and stored crops. Total losses were approximately 1,840 million dollars, with 92 percent of the losses occurring in agriculture and 74 percent of the damage occurring in cotton crops (Pakistan Economic Survey, 2011). There were approximately 434 deaths due to this flood, approximately 5.3 million people were displaced, and approximately 1,524,773 homes were partially or fully damaged (Aon plc, 2010).

Flash floods occurred in KPK, Sindh, and Punjab provinces in 2013 as a result of heavy rains during the monsoon season. Pakistan floods in 2013 have not only resulted in the loss of human lives, property, and infrastructure but also caused severe damage to agriculture. It has been estimated that the floods of 2013 have affected a cropped area of approximately 1.107 million acres, affecting 8,297 communities' areas, claiming 333 lives, fully damaging 33,763 houses and partially damaging 46,180 houses, and affecting a population of approximately 1.489 million people. Over the past 66 years, Pakistan has lost more than US$ 37.554 billion in financial losses. A total of 603,942 square kilometers were affected by 21 major flood events from 1950 to 2013 causing 11,572 deaths, and 188,531 villages to be damaged/ destroyed (Ministry Of Water and Power, 2013).

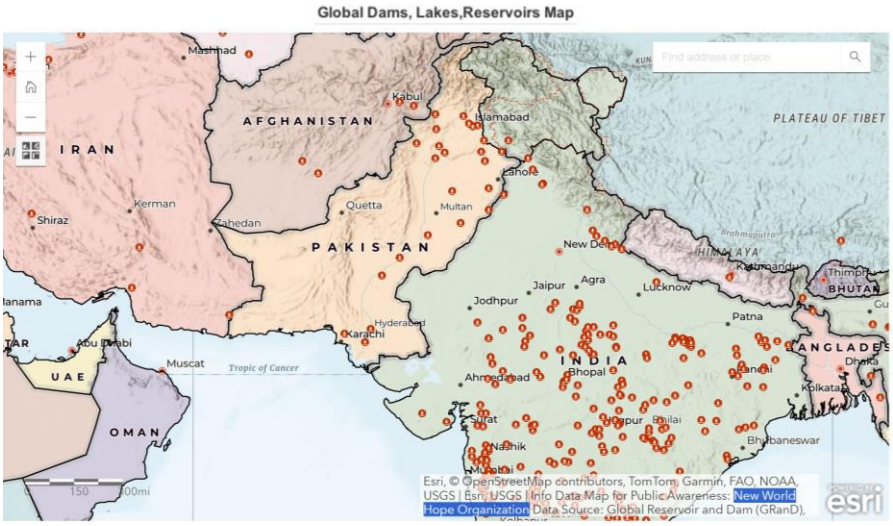
In 2014-15, heavy monsoon rains affected the central region, Punjab, and the eastern regions, Gilgit Baltistan and Azad Jammu and Kashmir, of the country for the fourth consecutive year. This natural disaster resulted in the deaths of approximately 367 people and the displacement of approximately 2.5 million people. A total of one million acres of agricultural land and approximately 2.5 hundred thousand farmers were adversely affected (Yaqub & Eren, 2015).

There were severe floods in Pakistan in June 2022. Three-quarters of the country's landmass was under water, destroying over 3.6 million acres of crops and killing more than 750,000 animals. There have been almost 24,000 schools damaged, and thousands of roads lost. Floods affected infrastructure, crops, and food production, costing US$30 billion. Floods have affected about 33 million people, displaced over 7 million people, and killed over 1500, including 552 children. 16 million children and 650000 pregnant women have been affected by the floods (Ministry of Planning Development & Special Initiatives, 2022).

Causes of Floods in Pakistan

Since Pakistan was established, it has experienced more than 21 major floods, but the intensity and frequency of these floods have increased over the past decade. Around 70 percent of global disasters are caused by hydrometeorological events. Historically, heavy rainfall has been a major contributor to the continuity of devastating floods in Pakistan. Heavy rains raise the level of water in rivers and streams, and when the water level rises due to heavy rain, the riverbanks overflow and the water comes out from the banks, causing damage to surrounding areas and crops. A second main cause of floods is heavy and abnormal rains due to climate change and the melting of glaciers as a result of the changes in the weather. it is estimated that up to 73% of the runoff is generated by snowmelt and glacial melting. This results in an increase in the water ratio of rivers which eventually causes flooding (Taraky et al., 2021).

Another important factor that contributes to the occurrence of floods in Pakistan is the lack of management of water and the lack of big dams to control the levels of water. Flooding is one of the greatest risks to sustainable development in Pakistan. Generally, dams influence flooding frequency, duration, and timing by regulating water flow. Large-scale dams can control the discharge and prevent floods.



Shahzad Ismail's GIS Map Project 2023, Global Dams, Lakes, and Reservoirs Data Map, published at https://newworldhope.org/index.html

The Pakistani government relies heavily on its small and medium-sized dams and barrages in order to prevent rivers from flooding and to meet its energy demands. However, unfortunately, these dams and barrages were not able to control and reduce the frequency of recent floods that occurred in Pakistan. Therefore, there is an urgent need for a large dam that can not only fulfill the nation's electricity needs but also control and reduce the level of water in rivers during rainy seasons while providing valuable water storage for agriculture during the rainy season. In Pakistan, the economy is largely based on agriculture, and water resources are crucial to the economy. By constructing the big dam, the country will be able to boost agricultural output, give livelihood opportunities to those in need, and contribute to the improvement of their living conditions. One of the primary goals of dam construction is to control floods and disasters (Nazeer, 2020). Despite this, the dam is not able to meet the country's needs. The increasing population and climate change have a profound impact on water and water management. The increasing water demand, coupled with more frequent flood occurrences, places significant pressure on this vital resource. By implementing sustainable water management practices, such as water reservoirs, water recycling, and rainwater harvesting, we can mitigate the challenges posed by population growth and climate change and ensure long-term availability and access to clean water for all. (Janjua et al., 2021).

Pakistan's Flood Protection Facilities

There are several policies and institutions in place by the Pakistani government such as Flood Policy and Strategy to ensure effective and sustainable flood management, Flood Institutions to implement structural and nonstructural interventions, Flood Risk Managing Institutions (FRMI) to promote sustainable and long-term flood resilience, and Flood Crisis Management Institutions to supervise and direct rescue at local and national levels. (Ministry Of Water and Power, 2013).

Even though there are currently many flood management and preparedness measures in place in Pakistan to ensure effective and sustainable flood management, Pakistan has made significant strides in improving flood management through various measures. However, the country still faces challenges in implementing a comprehensive and sound flood management system that can adequately mitigate the devastating impacts of these natural disasters. Based on the current situation, there is an urgent need to create an effective flood management system that can deal with floods in a responsible manner (Department of Civil Engineering, The University of Lahore, 2018; Ministry Of Water and Power, 2013). There is still one crucial element lacking in Pakistan despite the implementation of flood policies, flood laws, flood think tanks, flood management institutions, and flood crisis management organizations - the construction of large dams that can control and manage flood water both during and after floods.

Economic Benefits of Dam Construction

Dam construction offers several key economic advantages, including increased agricultural productivity, tourism development, and enhanced electricity production ability. These advantages contribute to economic growth, job creation, and sustainable development, making them important features for the overall development and prosperity of a country.

Increased Tourism and Fisheries

The tourism sector is a significant generator of economic activity on a rapid and broad scale. Before the COVID-19 pandemic, the World Travel & Tourism Council (WTTC) report revealed that the employment in the travel and tourism sector of Pakistan in 2019 was 3,888 thousand. Pakistan's neighboring countries such as India generated employment through travel and tourism in 2019, reaching about 40,104 thousand, which is almost 10 times higher than Pakistan. Additionally, China's travel and tourism employment rate for 2019 was approximately 82, 240 thousand, which is 21 times higher than Pakistan. In terms of contribution to GDP, China's travel and tourism sector generated $1,665.6 billion in 2019, while the sector contributed $191.3 billion to India's economy in the same year. However, it is important to note that Pakistan is not on the list of G20 countries list so in the WTTC report, so there are no GDP data available for Pakistan (WTTC, 2022).

Pakistan's ranking in the Travel and Tourism Competitiveness Index for 2019 was 121 out of 140 countries, while India was placed at 34 and China at 13. In the Asia Pacific region, Pakistan is ranked at the bottom of the list (World Economic Forum, 2019). There is a significant need to improve Pakistan's travel and tourism sector in order to generate an environmentally friendly environment and enhance employment opportunities in the country. Recognizing the importance of improving the Travel and Tourism sector in Pakistan, a number of measures can be taken to enhance the eco-environment and generate employment opportunities in the country. Building dams is considered an ideal option in this regard. By investing in dams, Pakistan can generate hydroelectric power, improve water resources, and create opportunities for recreational activities such as boating and fishing. The presence of a dam in any area can contribute to the development of infrastructure such as guesthouses, restaurants, and parks, further enhancing the overall tourism experience for national and international tourists. This, in turn, can boost tourism in the country and generate new job opportunities.

Boosted Agriculture

The (Finance Division, Government of Pakistan, 2022) report emphasizes the importance of sustainable growth in the agriculture sector for food security and rural development in the country. With a contribution of 22.7 percent to the Gross Domestic Product (GDP), agriculture plays a significant role in the economy of Pakistan. Additionally, it employs around 37.4 percent of the labor force, highlighting its significance in terms of job creation and poverty reduction.

There are frequent floods and droughts in the river basin. During a flood, infrastructures are destroyed, urban and rural areas are inundated, and agricultural land is damaged. The Pakistan Council of Research in Water Resources (PCRWR) report highlights that water interests in the country are often conflicting when it comes to water use in agriculture. There is a need to improve the productivity of the agricultural sector in the report. Agricultural activities consume a significant amount of freshwater and play a crucial role in food security. The report highlights the construction of dams is essential for several reasons. They enable the transfer of flows from the high-flow rainy season to the dry seasons, ensuring a consistent water supply throughout the year. Dams play a vital role in ensuring an adequate and reliable water supply for agriculture, especially during drought periods. By capturing and storing water, dams help mitigate the impact of water shortages on agricultural productivity, ensuring food security for the population (Fatima et al., 2021).

Increased agricultural production can have several significant benefits, both in terms of economic returns and food security for the country. Dams play a crucial role in harnessing the stored water, regulating its release, and ensuring a steady water supply for agricultural purposes. Dams contribute to the overall economic development of a nation by increasing crop yields and providing a reliable water supply. When farmers have access to sufficient water, they can cultivate a wider range of crops, leading to increased production. Dams not only increase the amount of food available but also create job opportunities in the agricultural sector.

Increased Electricity Production

The energy area is one of the most important components of any country's economic development. Over the last two decades, there has been a substantial increase in the energy demand. However, the energy sector in Pakistan has been facing challenges for quite a long time. One such challenge that persists is the long-standing issue of circular debt in the energy sector. Circular debt in the energy sector refers to the accumulation of overdue payments and pending liabilities, leading to a financial imbalance(Finance Division, Government of Pakistan., 2022). Despite facing these challenges, Pakistan's energy needs continue to grow, with the demand for energy expected to rise significantly in the coming years. This increasing energy demand, driven by population growth, will put increasing pressure on the country's existing energy resources and distribution systems. However, the generation capacity of electricity has not kept pace with the power demand, leading to a persistent electricity demand shortfall of about 5000 megawatts (MW) since 2007, leading to long hours of load shedding in both rural and urban areas. In 2022, the shortfall stood at 5,944

MW, highlighting the need for urgent measures to address this problem. (PEC et al., 2014; Bokhari, 2023).

To address this issue, Pakistan can consider harnessing hydroelectric power generation. Building dams can provide a reliable and affordable source of power, contributing to the overall development of the energy sector. By investing in dam and hydroelectric power generation, Pakistan can overcome the electricity demand shortfall and contribute to its economic development. The dam is not just a structure used to generate hydroelectric power; it also plays a key role in providing a clean and renewable energy source for both domestic and industrial use. The process of eco-friendly electricity generation can result in changes to the ecosystem, potentially impacting fish populations and habitats and the tourism sector.

Features of the Proposed Dam - The Construction of a Dam and Its Assumption

Consider that floods in Pakistan cause an average annual loss of $3.6 billion. These floods cause immense damage to infrastructures and the economy, resulting in billions of dollars of losses. it is imperative to explore ways to reduce the total damage caused by these floods.

Reducing Damages by 5% with the Dam

One potential solution that can help decrease the damage caused by floods is the construction of a dam. A dam is designed to store and control the flow of water, decreasing the risk of floods and the resulting destruction. However, it is critical to note that preventing all damage caused by floods is virtually impossible. The dam will contribute to the generation of electricity through its 2 MW electricity turbines. This paper aims to reduce the overall damage caused by floods by 5%. To achieve this, it is estimated the average cost of floods per year is $3.6 billion. By reducing this cost by 5%, we can save approximately $188 million in damages annually.

The Dam Location

In the northeastern region of the country, where mountains are abundant, the construction of a dam will be undertaken. The mountain geography of the region presents several advantages that will make the construction process easier than in other parts of the country. Firstly, the presence of mountains will provide a natural barrier against erosion. This will lessen the risk of landslides and other natural hazards that can hinder dam construction. Additionally, the mountains can act as a natural source of construction materials, such as rocks and gravel, which can be harvested for the dam's construction. The northeastern region is known for its vulnerability to floods. Its location, surrounded by mountains and rivers, makes it more susceptible to flooding events. However, the construction of a dam in the region can help mitigate the flood risks. By storing water during the wet season and releasing it in a controlled manner during the dry season, the dam can help regulate the water flow and reduce the likelihood of devastating floods.

Tourism and Fisheries

The creation of a larger reservoir through the construction of the dam will bring about several opportunities for growth in tourism and fisheries. The scenic view of the reservoir will attract tourists, who can enjoy recreational activities such as boating, fishing, and hiking. Furthermore, the dam will stabilize the water conditions and provide a conducive environment for the growth of fish and other aquatic species, resulting in increased fishing activities. A tourism and travel impact of 0.075 percent is expected on the country's GDP due to the dam construction.

Electricity Generation

In addition to its benefits for flood control and irrigation, the dam will also contribute to the generation of electricity. Equipped with 2 megawatts (MW) hydropower turbines, the dam can generate sufficient power to meet local demand or supply excess electricity to the grid. This will not only contribute to the sustainable development of the country but also provide opportunities for economic growth through the sale of electricity to neighboring areas. It is estimated that the dam will generate sufficient power and generate $2.5 billion in revenue.

Life Span Assessment of the Dam

The life span of the dam is a crucial factor that requires careful consideration. Due to the high sediment load carried by the river and the severe floods and heavy rains that occur during the rainy season, it is expected that the dam may experience wear and tear over time. However, the assumption that the life span of the dam will be 50 years is based on the absence of any upstream dams. The presence of an upstream dam could potentially affect the sediment flow patterns and mitigate the detrimental effects on the dam's structural integrity. Additionally, the effectiveness of flood control measures can also be influenced by the presence of other dams along the river. These factors need to be thoroughly evaluated when determining the life span of the proposed dam.

Costs

Building a dam is a complex and costly endeavor. When considering the construction of a dam, it is important to take into account several costs associated with the project. These costs include not only the initial construction costs but also ongoing expenses.

The Cost of the Land

This analysis indicates that the government of Pakistan is expected to pay approximately $20 million for the land where the dam will be built. It is important to note that this amount is subject to change, as it is possible that the actual cost could be less than the expected amount due to the nature of the area.

In addition to the land cost, the government will also incur an additional cost of approximately $2 million before the dam construction begins. This cost is considered an incremental cost, as it represents the additional expenses incurred at the beginning of the project.

Overall, the total cost of acquiring the land and commencing the project is estimated to be around $22 million. However, it is important to note that this estimate is subject to change and may be modified based on further analysis and evaluation.

The Cost of the Construction.

Based on the estimates derived from similar dam projects, it is anticipated that the construction of the dam will cost approximately $1 billion. This estimation takes into account factors such as the complexity and scale of the project.

The construction of the dam is expected to take six years, starting from the initial planning stages to completion. During this period, the project will incur various costs, including labor, materials, and equipment.

In the first year of construction, the annual cost of the project is estimated to be $166.7 million. This figure takes into account the initial setup, procurement of materials, and initial labor expenses. It does not include ongoing maintenance costs or any additional costs associated with unforeseen challenges or delays.

It is significant to note that the cost of the program may increase or decrease throughout the construction phase. Factors such as changes in market conditions, variations in material prices, and delays due to unforeseen circumstances can all impact the final cost.

To ensure a smooth and efficient construction process, it is crucial to manage costs effectively and allocate resources efficiently. Regular monitoring of project progress, adherence to timelines, and proactive management of potential risks can help mitigate any cost deviations.

The Cost of the Main Maintenance

The cost of the main maintenance for dams is estimated to be 25% of the total project cost. This percentage was determined based on information from other projects and aligns with the recommendation that dams undergo major maintenance every 25 years.

The main maintenance project will involve various areas of the dam, including the walls and reservoir areas. It is crucial to ensure that these structures are in good condition to prevent leaks and potential hazards. The cost of the main maintenance is estimated to be $250 million, which is equivalent to 25% of the total project cost.

It is planned to conduct the main maintenance during the 25th and 26th years after the construction is completed. By scheduling the maintenance at these specific time points, the dam can be effectively maintained, and any potential issues can be addressed promptly. Regular maintenance will not only extend the life of the dam but also ensure its safety and functionality.

The Cost of the Regular Maintenance

As part of the regular maintenance, it will be carried out every 7th to 50th year. For a dam of this size to function correctly, it is recommended that such large constructions require regular and permanent maintenance to ensure they are working properly. According to our estimates, the annual cost of regular maintenance is estimated at $50 million. Regular maintenance consists of the cost of the machinery and equipment that needs to be maintained. As part of the regular maintenance program, the electricity turbines and other equipment related to the operation of the electricity turbines will also have to be maintained.

The Cost of the Electricity Turbines

The dam will be equipped with 2 megawatts (MW) hydropower turbines for electricity generation. These turbines will have a capacity of 180 MW each, and the total cost of installing them is estimated to be approximately $10 million for both units. Each turbine will produce 180 MW of power, and both turbines together will have a maximum nameplate capacity of 360 MW.

The turbines are scheduled to enter the construction phase in the 7th year of the project, which coincides with the anticipated completion of the dam. This staggered construction schedule allows for a seamless transition from the dam's construction phase to its operational phase. By having the turbines installed in the 7th year of construction, the dam will be able to meet its power demands efficiently and sustainably. This arrangement ensures a consistent and reliable power supply for the surrounding communities, while also minimizing the environmental impact associated with energy production.

Overall, the installation of these hydropower turbines at the dam represents an important step towards harnessing renewable energy and providing a reliable power source for the local community. The projected capacity and estimated cost of the turbines indicate their suitability and efficiency in delivering the required power output. During the life cycle of these turbines, it is anticipated that they will need to be replaced every ten years. This regular maintenance is

necessary to ensure the efficiency and reliability of the turbines. By replacing the turbines periodically, the dam can ensure a consistent supply of electricity to the surrounding area.

Overall, the cost of installing the electricity turbines for the dam is a significant investment, but the benefits in terms of power generation and reliability make it a worthwhile project.

The Cost of the Labor

The cost of labor for the construction phase of a dam is estimated at $127.8 million for six years. This calculation assumes of employing 250 engineers, 500 foremen, 2500 construction workers, and 500 support workers during the construction phase (years 1 to 7).

The minimum wage set by the government of Pakistan is 55,068 Pak Rupees, which is equivalent to $194. Therefore, the total cost of labor on an annual basis is estimated at $21.3 million.

It is important to note that there will be a total labor cost of $127.8 million during the construction phase of the project. This figure takes into account the annual salary and benefits of all the aforementioned employees.

In addition to the construction phase, the main maintenance work will be conducted during the 25th and 26th years. For this maintenance work, an estimated $42.6 million will be spent on labor. This investment is necessary to ensure that the dam remains operational and meets the necessary safety standards.

In summary, the cost of workers for the construction of a dam is approximately $127.8 million, which includes both construction and maintenance expenses. This amount takes into account the cost of employing various personnel, including engineers, foremen, construction workers, and support workers, as well as the minimum wage set by the government of Pakistan.

The following analysis assumes that the wages below mentioned are paid on a monthly basis;

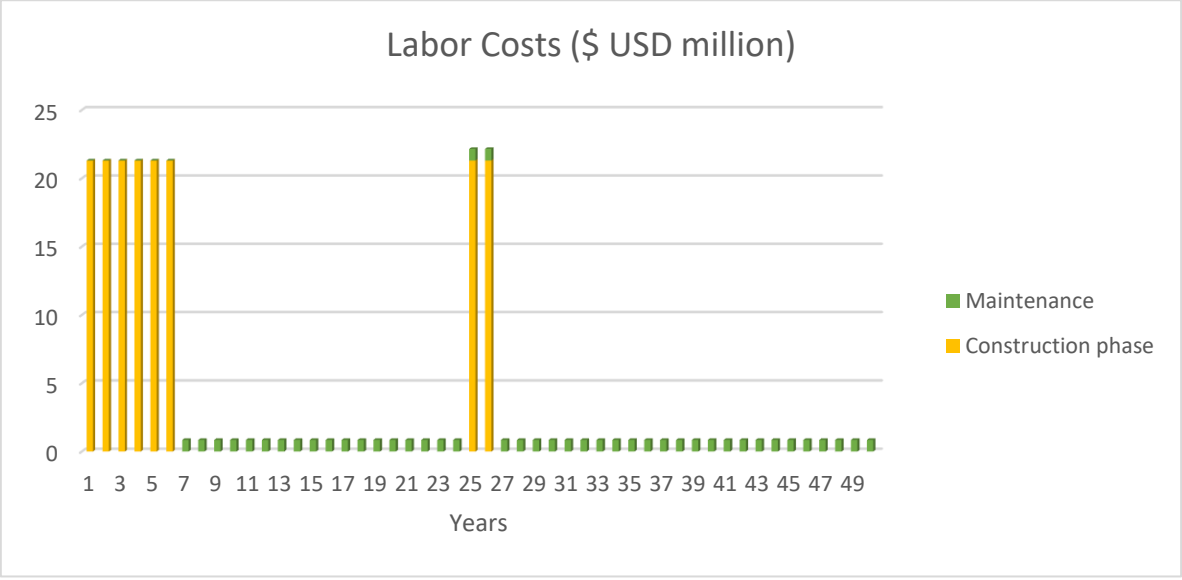
Supporter workers; $450

Construction workers; $500

Foremen; $650

Engineers; $800

Table. Labor costs during the project cycle



The cost of labor for the construction of a dam is a crucial consideration in the overall cost of the project. To ensure the success of the construction, a sufficient number of engineers and foremen will be employed to oversee and guide the workers. Once the dam is completed, regular maintenance will be essential for its continued functionality. This involves employing a team of engineers, foremen, workers, and support workers to carry out the necessary inspections, repairs, and replacements.

On the other side, after the construction of the dam, regular maintenance will take place. During this period, the following number of individuals will be employed, which may be increased depending on the circumstances.

- 10 engineers, - 20 foremen, - 100 workers, - 45 support workers

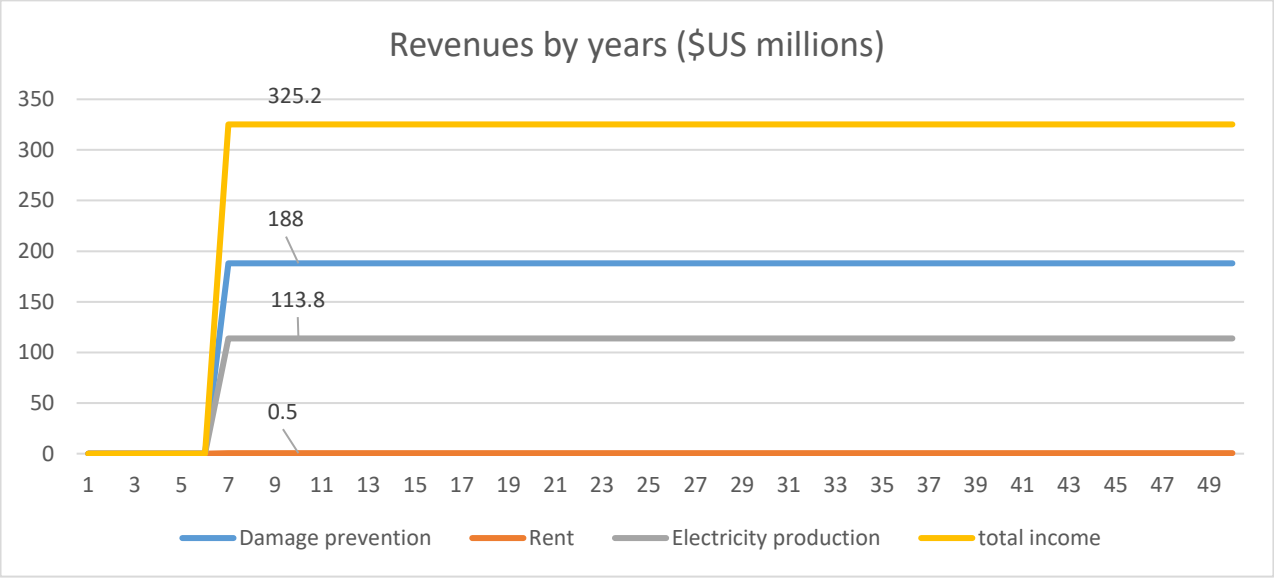
The yearly labor cost for regular maintenance is estimated to be $850,000, and the total cost for the entire project is estimated to be $37.4 million over 43 years.

The total labor cost for the entire project is estimated to be $207.8 million.

Revenues of the Dam

By constructing a dam, several kinds of revenues can be generated according to similar projects that have already been completed. This analysis is going to be divided into two groups based on the main benefits: direct revenues and indirect gains. The direct revenues are generated by electricity revenues rents, and tourism while the indirect revenues are generated as a result of increased agricultural production and damage prevention.

Table. Revenues by years



Electricity revenues

The plan to develop a hydroelectric power plant in the dam involves the installation of two turbines with a capacity of 360 megawatts (MW). This ambitious project aims to capitalize on the vast water resources available in the dam and harness them for electricity generation. By harnessing the power of water, the plant will not only ensure a reliable power supply but also contribute to reducing carbon emissions.

Hydropower is currently the largest renewable power generation source, accounting for a significant portion of the US energy mix in 2021. With its significant potential to reduce carbon emissions, hydroelectric power continues to be an attractive option for sustainable energy development. One of the key advantages of hydroelectric power is its low cost compared to other power generation technologies. Research has shown that hydropower offers some of the lowest-cost electricity available. This affordability makes it an attractive choice for both developed and developing countries, particularly in the context of energy security and affordability concerns (Musa et al., 2023).

In addition to cost-effectiveness, hydropower generates electricity without burning fossil fuels, making it a greener alternative to traditional power sources. By displacing other forms of power generation, hydroelectric power can contribute to reducing greenhouse gas emissions and mitigating the impacts of climate change. It is important to note that all power plants have capacity factors, which vary depending on resources, technology, and purpose. While the average capacity factor for hydroelectric power plants around the world is 44%, it is important to note that this value can vary depending on factors such as the availability and intensity of water flow, as well as maintenance and operational efficiency. (Kumar et al., 2018).

The dam will be able to produce 182648 kWh of electricity within the hour and 4383562 kWh per day by setting up the 02 hydropower turbines. This capability will enable the dam to meet the electricity demand of approximately 2.5 million residents in Pakistan.

The dam is expected to generate some 1.6 billion kWh of clean electricity per year. This substantial amount will contribute to meeting the country's growing demand for electricity. By generating electricity through hydropower, the dam will provide stable and cheap energy to the country.

The cost of 1 kWh of electricity in Pakistan is currently around 10.06 Pak Rupees under 101 - 200 Units, dated in Jan 2024. This is equivalent to $0.036 per kWh. This pricing structure indicates the potential revenue generated by the electricity generated by the dam.

Once the dam is completed, its revenue is expected to amount to about $57.3 million per year. In Pak Rupees, this translates to approximately 16.2 billion Pak Rupees per year. This revenue generation will contribute to the financial stability and sustainability of the project.

Creating Local Employment Opportunities

The construction of the Hydropower dam, a highly anticipated project, is expected to have a significant impact on the local job market. It is estimated that the dam will generate approximately 2000 local job opportunities on an annual basis. These jobs will not only provide employment but also contribute to the economic development of the region.

Tourism Development

Many dams have become popular tourist attractions, attracting visitors for their scenic beauty and recreational options. The revenues generated from tourism activities, such as guided tours, recreational facilities, eco-park, and visitor fees, can be a significant source of income for the dam's owner. Dams can provide opportunities for fishing and recreation, attracting anglers and other outdoor enthusiasts. The revenues generated from these activities, such as fishing licenses and facility rentals, can further enhance the economic impact of the dam. The dam is expected to have an economic impact on the country's GDP of 0.075 percent.

Rent

It is assumed that the government will receive an income of $0.5 million from the rental of its properties. Considering the recreational effects of the reservoir of the dam, it is likely that tourists will be attracted to it. It is anticipated that a variety of fisheries will be available in the area, as well as tourism facilities such as hotels, restaurants, and boat tours that may be leased out to private companies by the nature of the area. Receiving rent revenues will be possible after the sixth year.

Damage Prevention and Increased Agricultural Production.

Pakistan, being a developing country, relies heavily on agriculture for its economic growth and sustenance. However, the agriculture sector faces numerous challenges, one of which is the negative impact caused by floods. Floods pose a significant threat to both human lives and agricultural infrastructure, resulting in significant losses and disruptions to agricultural activities.

Over the years, floods have inflicted significant damage on Pakistan's agricultural sector. These natural calamities not only destroy crops and agricultural land but also disrupt the entire agricultural value chain. For example, as a result of the Pakistan floods of 2010, nearly 17 million acres of cropland were flooded. Pakistan's economy and crops were severely affected by the floods of 2010. The floods affected sugarcane crops for approximately $600 million; rice crops of $247 million; maize crops of $259 million; wheat stocks of $200 million; and fruit crops in the amount of $518,000. (Aon plc, 2010). A total of 2.9 million households were damaged, of which 1.9 were severely affected or completely destroyed, and 80% of food reserves were destroyed (Kirsch et al., 2012). To mitigate the adverse effects of floods and ensure sustainable water management practices, the construction of dams has become indispensable. Dams serve as vital infrastructure for water storage, regulation, and distribution. By capturing and storing excess rainwater, dams provide a consistent water supply throughout the year, enabling farmers to cultivate their fields even during dry spells. Agriculture is Pakistan's core industry, accounting for 25% of the country's GDP and 60% of its export earnings. Additionally, the industry employs about 60% of the population (Ismail & Malikr, 2020).

The implementation of dams has revolutionized Pakistan's agricultural sector in several ways. Firstly, dams enable farmers to cultivate crops throughout the year, leading to increased productivity and food security. By providing a reliable source of water for irrigation, farmers can cultivate off-season crops, diversifying their agricultural portfolios and enhancing the production cycle. Secondly, dams help mitigate the negative impacts of floods. By storing excess water during flood seasons, dams act as a buffer, preventing excessive flooding and ensuring the stability and sustainability of water resources for agriculture. This not only safeguards crops but also protects agricultural lands, infrastructure, and human lives. Furthermore, The dam will provide employment opportunities in the agricultural sector. The construction and maintenance of the dam will increase the country's economy contribute to overall development and contribute decent input to the country's economy.

Flood Damage in Pakistan: Economic Losses and Reconstruction Needs

Pakistan is a country prone to devastating floods, which cause significant economic losses and impact the country's GDP. Floods in Pakistan cause losses of about 10 billion dollars each year. These floods have a detrimental impact on various sectors, including agriculture, infrastructure, and public services. The average annual flood damage from 1960 -2011 has been estimated to be in the range of 1-5% of the mean annual GDP. However, the 2010 flood stands out as the most severe in terms of economic costs, exceeding $10 billion. This flood caused immense destruction, affecting millions of people and causing major disruptions to economic activities(The Asian Development Bank, 2013)

The Ministry of Planning Development & Special Initiatives Report Pakistan Flood 2022 estimates the damage and economic losses caused by the floods in 2022 to be more than $30 billion. The report also highlights the

need for reconstruction efforts, which will cost around $16 billion.

To mitigate the impact of flooding, there is a great need of the construction of a dam. This dam has the potential to significantly reduce the damage caused by floods. As indicated above, floods in Pakistan result in an average annual loss of $3.6 billion. The proposed dam is expected to reduce flood damage by 5%, which is equivalent to approximately $$188 million per year.

While the negative effects of climate change on floods are expected to increase in the future, we assume that the total amount of damage to the agriculture sector, livelihoods, communities, and infrastructure will remain constant for the next five years. However, after the sixth year of the proposed dam project, prevention will be available, offering protection to these important sectors.

Cost Benefit Analysis

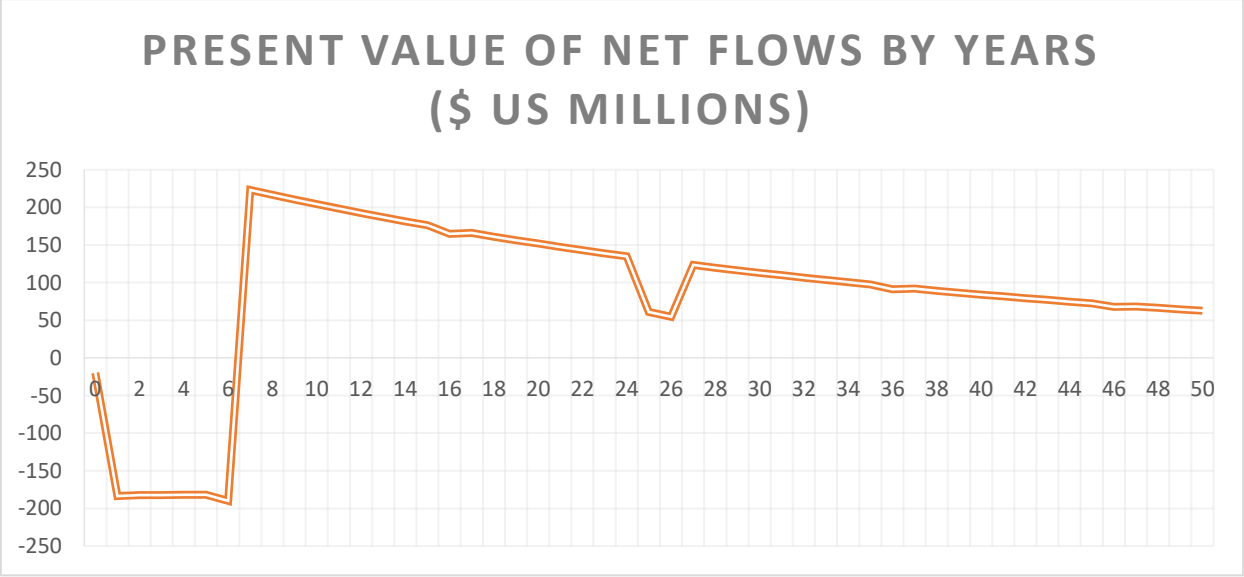
The cost-benefit analysis (CBA) is used to evaluate the benefits and costs of an intervention measured in monetary terms. This analysis is used to assess the feasibility and economic viability of the proposed dam project. By comparing the benefits generated by the proposed project with its costs, this analysis will help to determine whether constructing the dam is the best option available. The formula for calculating the cost-benefit ratio is Benefits/Costs. This ratio provides a snapshot of the financial viability and sustainability of the proposed dam project.

In the case of the proposed dam in Pakistan, the estimated life span of the project is 50 years due to the significant number of sediments carried by the river, frequent floods, and heavy rainfall. The total cost of the project is estimated to be $3.8 billion, encompassing the construction costs, transmission lines, and a reasonable estimate of potential cost overruns.

The total revenue estimated to be generated by the dam is estimated to be $22.5 billion. This revenue includes income from electricity, rent, tourism development, fisheries and recreation, agricultural production increase, and the prevention of damages. These sources of income provide a comprehensive picture of the impact of the dam on the local and regional economy.

The discount rate used in the analysis is 3%. This discount rate reflects the time value of money, considering the present value of future cash flows. Based on the assumptions made, the net present value of the net flow is equal to $8.1 billion. This value represents the present value of the economic benefits generated by the project. The cost-benefit ratio for the proposed dam project is estimated to be 5.9. This means that the benefits outweigh the costs by a factor of 5.9. In other words, the construction and subsequent operation of the dam will have positive effects on the Pakistani economy. However, it is important to note that the assumptions made regarding factors like river flow, efficiency of the dam, and access to markets can significantly impact the analysis of the investment.

Table. Present value of net flows by years



Sensitivity Analysis

In order to assess the robustness of the analysis, conducting a sensitivity analysis is a crucial step. This paper presents two sensitivity analyses conducted on the proposed dam project.

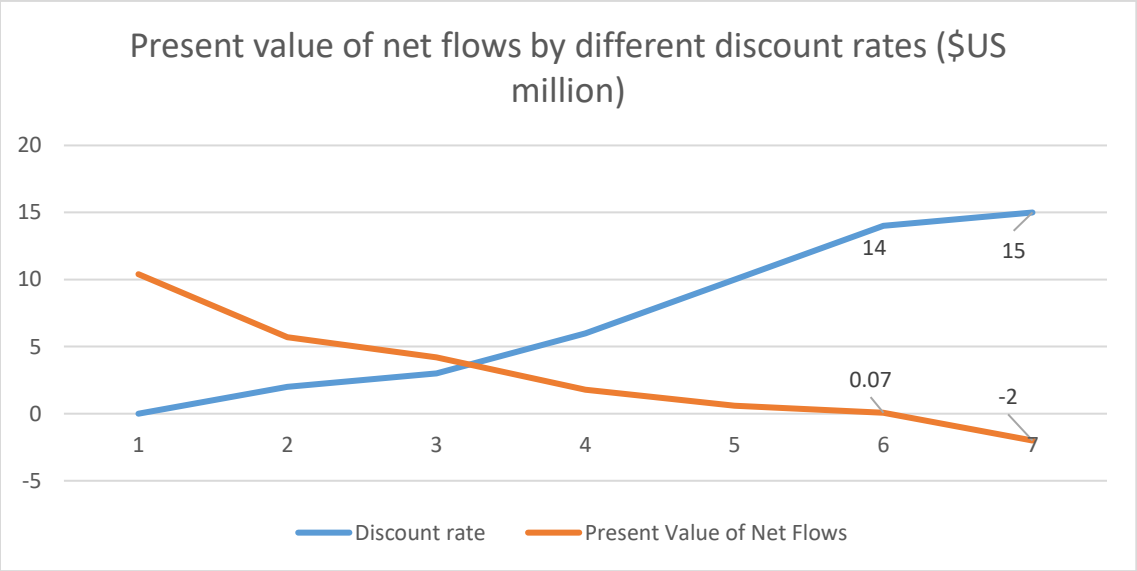
The first sensitivity analysis focuses on damage prevention. As mentioned above, the analysis foresees 5% damage prevention. However, it is crucial to explore the impact of varying this percentage. By reducing the damage prevention

rate to 2%, the impact on the cost-benefit ratio of the proposed dam can be observed.

According to the calculations, the cost-benefit ratio decreases to 2%. Despite this reduction, the present value of net flows remains positive, standing at $2 billion. This outcome signifies that the project would still yield economic benefits even at a lower damage prevention rate.

The second sensitivity analysis examines the sensitivity of the results to the discount rate used. The calculations assume a discount rate of 3%, but it is relevant to explore how changes in this rate may affect the financial viability of the proposed dam. If the discount rate does not exceed 14%, the present value of net flows remains positive. This signifies that the proposed dam is financially viable under a range of discount rates, providing confidence in the results.

Table. Present value of net flows by different discount rates.



IV. LIMITATIONS TO THE STUDY

As mentioned in this paper, the cost-benefit analysis employed several assumptions. This can be attributed to several factors, one of which is a scarcity of reliable and readily available data. Additionally, the presence of policy recommendations also plays a role in the reliance on assumptions. The construction costs, regular maintenance expenses, and electricity turbine costs are all estimated using assumptions, enabling the calculation of the total cost. As determining the cost of a similar project was not feasible, revenue was estimated based on assumptions as well.

One of the challenges encountered during the analysis is obtaining accurate cost estimates, as precise information is unavailable. As a result, numerous assumptions have been made to complete the analysis. To validate these assumptions, a sensitivity analysis will be conducted to examine their impact on the overall findings.

One reason for this assumption is the inability to calculate the actual capacity factor of an electricity turbine before it has been put into operation. This factor can only be determined after the turbine has been put into operation. Similarly, predicting the impact of future floods is challenging. The amount of rainfall can vary significantly, leading to higher or lower flooding levels compared to previous occurrences. Consequently, the impact of floods cannot be accurately estimated until it occurs.

V. CONCLUSION

A dam serves a variety of purposes, including storing water for irrigation, agriculture, tourism promotion, providing drinking water, and protecting against flooding. However, Pakistan, a country facing severe water scarcity, has become handicapped in terms of development and economic growth. The demand for water in Pakistan is expected to multiply five times by 2050 due to population growth. The agriculture sector heavily relies on water resources, which is decreasing at an alarming rate. The harmful effects of climate change on the country's limited water resources further exacerbate the situation. To address these issues and ensure the protection, management, and sustainability of water in Pakistan, the construction of small a dam and the implementation of water conservation measures in both rural and urban areas is crucial. These measures have the potential to alleviate water scarcity, promote agricultural development, and ensure a more sustainable future for the country (Ismail & Malik, 2020). Pakistan has made a lot of efforts to establish various flood management systems, policies and institutions, but the absence of a large dam

continues to be a pressing issue. Instead of investing heavily in manpower to establish institutions, systems, and policies, Pakistan must prioritize the construction of a large dam. This dam would serve as a significant barrier against flood waters, protecting lives and infrastructure from the devastation caused by floods. Additionally, it would enable the country to better manage and store excess water, preventing future floods from reaching such devastating levels. The construction of such a dam would not only alleviate the damage caused by floods but also contribute to the overall development and prosperity of the country.

The paper aims to analyze the cost-benefit analysis of building a big dam to mitigate floods, promote tourism, boost agriculture, and generate electricity. The cost-benefit analysis conducted in the paper has demonstrated the significant benefits of constructing such a dam. Firstly, it will provide significant relief to Pakistan's agriculture sector by reducing the negative effects of floods. By effectively managing floodwaters, the dam will help safeguard crops and prevent significant financial losses caused by crop destruction. Furthermore, the proposed dam can bring significant economic benefits for both the government and communities nearby. From travel and tourism opportunities to revenue generation through tourism taxes, fishery licenses, eco-friendly parks, guest houses, and recreation activities, the construction of this dam offers opportunities for sustainable growth and economic progress. Pakistan is a country with a rich cultural heritage and a diverse range of attractions for visitors. However, despite its potential, the travel and tourism sector in Pakistan is not meeting its full potential. The travel and tourism sector can play a vital role in Pakistan's economy. It can contribute to more job creation, foreign exchange earnings, and infrastructure development and can serve as a recreational destination, attracting visitors and promoting tourism-related activities. This could provide an additional source of revenue for the government and help boost the local economy.

Moreover, the project offers an opportunity to harness clean energy for Pakistan. By utilizing the power generated by the dam, the government can significantly reduce its reliance on external sources of power generation and promote sustainability. This will not only benefit the country economically but also contribute to the fight against climate change.

The paper's findings clearly indicate that building a big dam is a highly beneficial project for Pakistan. the cost-benefit analysis clearly demonstrates the numerous benefits of constructing a dam. By mitigating flood damage, preventing human losses and damages, boosting agriculture, and promoting clean energy generation and the tourism sector, the dam provides significant contributions to the government and society as a whole. It is an investment that not only addresses immediate challenges but also lays the foundation for a sustainable future. Moreover, it has the potential to create a positive impact on the tourism sector. Given the aforementioned advantages, this paper strongly recommends Pakistan Government consider constructing such a dam.

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