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**Pakistan Engineering Congress is a prestigious professional body established in 1912 dedicated, interalia to technical advancement of Science & Engineering in the country**

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# PROFILE OF PRESIDENT
# ENGR. NAJAM WAHEED

Engr. Najam Waheed obtained his Bachelor's Degree from University of Engineering & Technology, Lahore in Civil Engineering. He has over thirty years of multifaceted professional experience leading and pursuing development and engineering projects which includes planning, project management, preparation of technical reports and contract documents. He is well-versed in various national and international codes, regulations, quality standards and their implementation. He worked on various prestigious and technically complex projects.

Engr. Najam Waheed has been a Council Member of Pakistan Engineering Congress for more than two decades. He has been an active member of the Congress serving as Secretary, Joint Secretary, Treasurer, and Convener of all important Committees of the Congress, and was elected as the President of the Pakistan Engineering Congress in December 2021. His vision has been manifested in a digital transformation of the Congress's services and has laid a strong foundation for future growth and developments of Engineers Communities.

His dedication to engineering development and the Pakistan Engineering Congress played a significant role in developing effective synergies with important professional bodies in the country, which would significantly contribute to engineers professional competence in a challenging environment of disruptive technologies and sustainable development.



**Engr. Najam Waheed**
**President**
**Pakistan Engineering Congress (77th Session)**

## EDITOR'S NOTE

World Environment Day is the United Nations' principal vehicle for encouraging worldwide awareness and action for the environment. Held annually since 1973, the Day has also become a vital platform for promoting progress on the environmental dimensions of the Sustainable Development Goals. With the United Nations Environment Programme (UNEP) at the helm, over 150 countries participate each year. Major corporations, non-governmental organizations, communities, governments and celebrities from across the world adopt the World Environment Day brand to champion environmental causes

This year's World Environment Day campaign focused on land restoration, desertification and drought resilience under the slogan "Our land. Our future. We are #GenerationRestoration".

According to the UN Convention to Combat Desertification, up to 40 per cent of the planet's land is degraded, directly affecting half of the world's population and threatening roughly half of global GDP (US$44 trillion). The number and duration of droughts has increased by 29 per cent since 2000 – without urgent action, droughts may affect over three-quarters of the world's population by 2050.

Land restoration is a key pillar of the UN Decade on Ecosystem Restoration (2021-2030), a rallying call for the protection and revival of ecosystems all around the world, which is critical to achieve the Sustainable Development Goals. 2024 will mark the 30th anniversary of the UN Convention to Combat Desertification. The sixteenth session of the Conference of the Parties (COP 16) to the United Nations Convention to Combat Desertification (UNCCD) will be held in the Saudi capital, Riyadh, from 2 to 13 December 2024. Saudi Arabia pledges to plant tens of billions of trees in the country and wider region to combat drought, desertification, and land degradation.

Here are seven ways to get involved in ecosystem restoration on World Environment Day as outlined in the practical guide.

i. Make agriculture sustainable
ii. Save the soil
iii. Protect the pollinators
iv. Restore freshwater ecosystems
v. Renew coastal and marine areas
vi. Bring nature back to cities
vii. Generate financing for restoration

Environment protection and conservations development program in Pakistan draws its inspiration from Stockholm Convention of 1972 held under the umbrella of United Nations. As environment protection ordinance was enacted in 1983 as a starting, followed by National Conservation Strategy (NCS) in 1992. The culmination came in 1997

with enactment of Pakistan Protection Environment Act specifying the National Environment Quality Control Standards as a Benchmark. In 2001 the Government of Pakistan formulated the National Action Plan to arrest the ever-increasing degradation of Environment mainly due to man made errors of Commission.

Pakistan, like many countries around the world, faces significant environmental challenges that threaten the health and well-being of our people and the sustainability of our natural resources. From air and water pollution to deforestation and habitat degradation, the stakes have never been higher.

As members of the engineering community, we have a moral obligation to lead by example and drive positive change in our society. Whether it's through sustainable infrastructure projects, renewable energy solutions, or innovative waste management practices, engineers have the power to make a tangible difference in the fight against environmental degradation.

It is well known saying that the trees are lungs of the Earth but human being depleted natural resources, cut down forests, led to pollution and global warming. It is high time that we turn to nature and start pursuing it. Every year World Environment Day is observed to raise awareness about climate change, global warming, deforestation and loss of biodiversity.

As Generation Restoration, we have a responsibility to act. Countries must fulfill their commitments to restore degraded ecosystems and land. We must use our national climate action plans to halt and reverse deforestation. We must significantly increase financial support for developing nations to adapt to extreme weather, protect nature, and promote sustainable development.

Remember, inaction is costly, but effective action makes economic sense. Every penny invested in ecosystem restoration yields up to thirty times in benefits. Let us work together to build a sustainable future for our land and humanity.

Let us commit ourselves to embracing innovation, collaboration, and solidarity in our efforts to restore our lands, enhance our resilience, and combat desertification. Together, we can make a meaningful difference and leave a positive legacy for the planet and future generations.

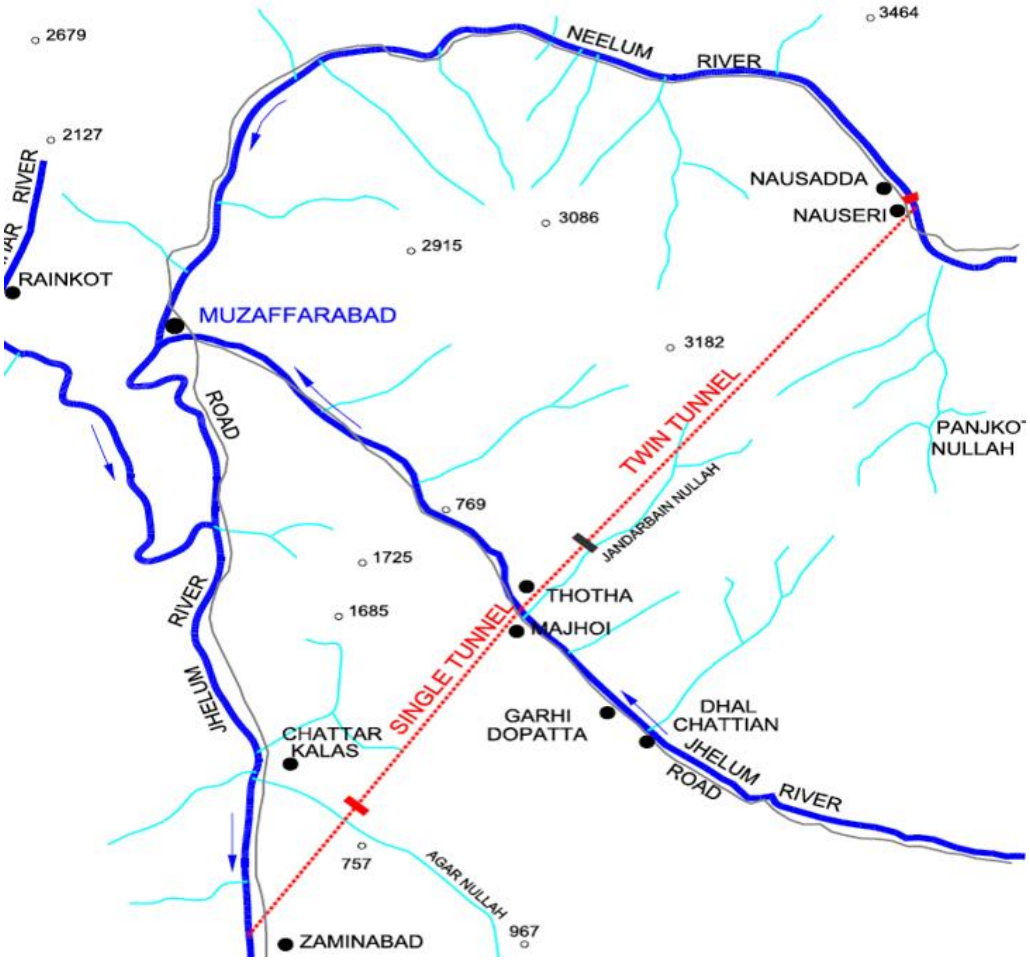
## VISIT OF PEC DELEGATION TO NEELUM-JHELUM HYDROPOWER PROJECT ON

## NOVEMBER 14-16, 2024

A Twelve Members strong delegation of Pakistan Engineering Congress led by ***Engr. Amjad Saeed, Engr. Iftikhar Ahmed***, Former President(s) Pakistan Engineering Congress & ***Engr. Dr. Muhammad Riaz***, Member Executive Council/Chief Editor paid a Technical Visit to Neelum-Jhelum Hydropower Project on November 14 to 16, 2024. The delegation was welcomed by ***Engr. Gul Mir Khan***, Chief Engineer/Project Director of the Project. The delegation was apprised of the salient feature of the Project. After that, the delegation was escorted to have a look around the Project Site. At the conclusion of the visit Pakistan Engineering Congress shields and publication were presented to ***Engr. Gul Mir Khan*** Chief Engineer/Project Director and to ***Engr. Afsar Mir***. It was a very informative visit.

## BRIEF OF NEELUM-JHELUM HYDROPOWER PROJECT

The Neelum-Jhelum Hydropower Project is a significant run-of-the-river hydroelectric power project located in Azad Jammu and Kashmir, Pakistan. The project is designed to divert water from the Neelum River to a power station on the Jhelum River, with the powerhouse situated near Chattar Kalas, approximately 42 km south of Muzaffarabad.



**Key Features and Specifications:**

**Dam and Tunnel System**: The project includes a composite dam (gravity and rock fill) with a height of 60 meters and a length of 160 meters. The tunnel system comprises twin tunnels, each 19.6 km long, a single tunnel of 8.94 km, and a tailrace tunnel of 3.55 km.

**Power Generation**: The installed capacity of the project is 969 MW, with four Francis-type turbines, each generating 242.25 MW. The project is expected to generate approximately 5.15 billion units of electricity annually.

**Hydraulic Head and Design Discharge**: The project operates with a gross head of 420 meters and a design discharge of 280 cubic meters per second.

**Construction and Commissioning:**

Construction of the Neelum-Jhelum Hydropower Project began in 2008, following the awarding of the construction contract to a Chinese consortium in July 2007. The project faced numerous delays due to rising costs and the 2005 Kashmir earthquake, which necessitated a redesign to meet more stringent seismic standards. The first generator was commissioned in April 2018, and the entire project was completed in August 2018.

**Financial Aspects:**

The total cost of the project was approximately Rs. 515 billion ($5.1 billion). The project was financed through various loans from international and local financial institutions.

**Environmental Impact:**

The Neelum-Jhelum Hydropower Project is designed to have minimal environmental impact, as 90% of the works are underground. The project has been constructed with careful consideration of environmental standards to ensure sustainability.

**Importance and Benefits:**

The Neelum-Jhelum Hydropower Project is of immense national importance for Pakistan. It not only contributes significantly to the country's power generation capacity but also helps in managing water resources more efficiently. The project plays a crucial role in meeting the energy demands of the region and supports the overall economic development of Pakistan.

**Technical Visit to Nelum Jehlum Hydropower Company November 14-16, 2024**



Engr. Afsar Mir Khan, Neelum Jehlum Hydropower Company is Briefing the Delegation about the Features and details








Formal Presentation at Conference Room of by Engr. Afsar Mir Khan of Neelum Jehlum Hydropower Company







Pakistan Engineering Congress Delegation having on site Briefing Discussing Various Structures of Neelum Jehlum Hydropower Project



Pakistan Engineering Congress Delegation Briefing about Power House of Neelum Jehlum Hydropower Project





Group Photo of the Delegation at Neelum Jehlum Hydropower Project



Group Photo of the Delegation at Neelum Jehlum Hydropower Project




Neelum Jehlum Hydropower Dam Detail







Engr. Amjad Saeed Former President-PEC, Engr. Iftikhar Ahmad Former President-PEC presenting Pakistan Engineering Congress Shield to Engr. Gul Mir Khan Chief Engineer & P.D, Neelum Jehlum Hydropower Company




Engr. Dr. Muhammad Saeed Member Executive Council presenting Pakistan Engineering Congress Shield

## HOW LANDSLIDES FUELED A CLIMATE WARRIOR'S FORESTATION DRIVE IN PAKISTAN

**By**

**Aamir Latif**

- Improved forest cover has spurred return of wildlife that was disappearing from the region

- Currently there are around 250,000 trees and plants in 50-acre mountain forest

**BAJAUR, Pakistan: Nestled on the Pakistan-Afghanistan border, the remote Bajaur tribal region, which was once a poster child for militancy, is currently in the headlines for a different reason: a feel-good success story of a climate warrior.**

Until recent years, landslides would regularly strike the tiny village of Maulana Khan Zaib, located on the foothills of a then-rugged mountain, causing casualties and infrastructure damage.

But this is no longer the case, just because of a small tree plantation venture initiated by Zaib, which in the next few years turned out to be a big success.

The then-barren mountain has been transformed into a lush green forest, not only holding off the landslides but bringing back the wildlife to the area.

"We had long been reeling from the landslides' damage until we realized it was because of the ruggedness of the mountain," Zaib, a religious scholar and social worker, told Anadolu.

He had discussed the plantation plan with his village mates, but the initial response was not very encouraging.

"I was not discouraged by that. They even laughed at me," Zaib, attired in a white shalwar-kameez (loose trousers and long shirt) and sporting a round cap, said.

He kicked off the project by planting 10,000 saplings.

The turning point in his ambitious venture was next year's rains that helped the plants grow, bringing some greenery to the mountain.

"There came an understanding and assistance from the village mates," Zaib, 42, who has a Master's degree in Islamic education, said with a wide grin.

### Wildlife returns to area

There have been no landslides in and around Zaib's village for the last several years due to improved forest cover.

Being one of the countries vulnerable to the ravages of climate change, Pakistan has gradually been losing its forest cover, mainly because of climate change impacts, firewood needs and intentional fires to increase agricultural land.

Several parts of northwestern Khyber Phaktunkhwa province, including Bajaur, have seen an increasing trend of intentional wildfires in recent years, burning thousands of acres of forest cover.

The dwindling forest cover also took a toll on the wildlife, with several rare bird and animal species disappearing from the region.

"Bajaur had been a green region until four to five decades ago. However, a gradual deforestation, particularly because of widespread tree cutting and intentional fires, has turned the mountains, including the one near my village, into a barren sight," Zaib said.

A military operation in 2008, which aimed to oust militants, also contributed to destroying the forest on the mountain that overlooks Zaib's village.

Currently, there are around 250,000 trees and plants spreading over a 50-acre mountain forest, according to Zaib.

The strengthening forest cover has spurred the return of wildlife to the region, including migratory birds.

"Wildlife had almost vanished from the area, but it has been revived in recent years due to increased forest cover," Shaikh Gul Baacha, another local climate activist, told Anadolu.

Not only have several local animals and birds been spotted in the forest but migratory birds have also started visiting the area again to spend winters over the past few years, he added.

Also, he said, the greenery has helped reduce temperatures in the adjoining villages in summers.

**'Climate change is a reality'**

Mohammad Saleem, a local tribal elder, heaps the blame for tree felling on the government, as the sprawling tribal district has no infrastructure for natural gas supplies.

"We all know the importance of trees. But what other option do we have except for (cutting down) trees, especially in the winter?" he said while speaking to Anadolu.

Partially supporting the argument, Zaib said the combination of a lack of basic amenities, including no gas supplies, and awareness has triggered deforestation in the region.

The provision of natural gas, he said, can help save the precious forests in the region, which are a "lifeline for us and our coming generations."

"Climate change is a reality, and we have to live up to this challenge."

***Courtesy: Published in Anadolu Agency (AA) Turkey, July 5th, 2024.***

## RETHINKING CPEC

**By**

**Syed Mohammad Ali**

**The China Pakistan Economic Corridor (CPEC) has been under implementation for nearly a decade now. CPEC was meant to draw much-needed investments in Pakistan's infrastructure and energy sectors at a time when the security situation in the country was uncertain, and American largess had begun to wither. Despite implementation delays, Chinese investments in CPEC are entering a second phase, so this is a useful time to examine how the first phase has fared, and to draw lessons from it.**

The Pak-China Joint Cooperation Committee (JCC) met recently to take stock of where things stand. In addition to further beefing up security for Chinese workers, the JCC reiterated the need for CPEC to deliver more growth, improve livelihood, enable innovation and catalyse a green transition. Despite building infrastructure and power plants, CPEC's record on these latter fronts is not very encouraging.

Thus far, CPEC has lacked local participation and transparency, which has worsened friction in sensitive places, such as Gwadar. China showed some largess by building a hospital, making sporadic relief contributions, and even announcing plans to provide a desalination plant for Gwadar. However, due to China's reliance on its own firms to provide managerial and technical skills and other inputs, and its inability to make the Gwadar port a hub for economic activity, we saw the emergence of a major protest movement 'Gwadar ko haq do tehreek' in 2022.

Whether CPEC's second phase projects — including building more roads and tunnels, another damn and a long-delayed railroad line linking Karachi to Peshawar — will offer more opportunities for the local populace remains to be seen.

Skeptics point to Chinese investments in 'white elephant' projects, such as the EXIM Bank funded Lahore metro rail project, as illustrations of 'debt diplomacy'. However, other donor funded reforms and development projects have also been susceptible to elite capture and often produced lackluster results. Pakistan's top-heavy Special Investment Facilitation Council (SIFC) has highlighted the need to expedite foreign investments in farming, mining, IT and defence production. Yet, unless existing project design and implementation mechanisms are modified, Chinese or other foreign investments in these sectors may do no more than produce low paying jobs and exacerbate environmental damage.

Pakistan must make greater efforts to align any incoming investments with compliance to labour and environmental safeguards to continue to avail preferential access to international markets (via the EU's GSP Plus, for example).

Pakistan also needs to make CPEC greener. The Pakistan-China Institute, in collaboration with the Sustainable Development Institute and Fudan University, has made useful suggestions in this regard. These recommendations call for shelving 'bad' projects and making environmental and social standards disclosure related to CPEC projects more robust. This research has also highlighted the need for turning CPEC planned Special Economic Zones (SEZs) into 'Eco-SEZs', which should encourage the use of renewables, ensure energy audits and emphasise recycling, which is also a good suggestion.

While Pakistan scrapped plans to install two more coal plants via Chinese financing, the government still seems keen on using its Thar coal reserves to produce dirty energy, which will worsen the air pollution problem. Instead of asking China to finance the conversion of imported coal projects to use local coal to lessen costs and enable loan repayments, Chinese input should be requested to help reduce power losses and improve energy efficiency instead.

Pakistan should invite China to pilot-test efforts to green the broader BRI via CPEC as well. The need to contend with climate change may also enable a green détente between China and the US, and Pakistan is well placed to enable such great power collaboration. However, Pakistani academic and research institutions need to proactively conduct research to identify and formulate measures to further investigate and test such possibilities.

***Courtesy: Published in The Express Tribune, July 5th, 2024.***

## SOARING ENERGY PRICES

**By**

**Sahibzada Riaz Noor**

**Electricity and gas prices are soaring. Power prices in Pakistan have a cumulative impact of up to 30% on overall inflation levels. The most seriously affected are prices of daily consumables, affecting living standards of the majority of the population, 40% of which live below the poverty line.**

There have been widespread public protests and outcries against energy bills increases and power shortages. The government has announced concessions in energy prices for lower-end consumers, but hardly 15-20% of users benefit therefrom, with the vast majority continuing to bear the brunt.

Electricity tariffs have increased from around Rs24-28 PKWH to an average of a staggering Rs76 per unit over the last few years, mainly on account of surging generation costs, energy debts, power losses and taxes. Pakistan has the distinction of being a country with one of the highest rates of energy pilferage, euphemistically termed 'line losses' that would not be possible without departmental collusion.

In 2020 the Aggregate Technical & Commercial (AT&C) losses of Pakistan's electricity sector stood at 29.7%, highest in the region. Sri Lanka had the lowest losses of 10%, followed by Turkey at 14.8%, Bangladesh 21.9%, India 23.9% and Nepal 24.4%.

This is a period of high electricity and gas prices with no apparent short-term remedy. Induction of measures of increasing share of cheaper sources of energy and upgrading transmission and distribution networks, to curtail line losses, could bring some amelioration, but results have so far proved elusive.

Electricity prices have increased and are anticipated to further enhance caused mainly by the gas and oil disruptions due to the Ukraine war and the fallout of the Israel-Gaza conflict on world energy prices.

The US, the UK and the EU are all facing energy inflation and shortages. Most of the European countries as well as Japan, China and India have stockpiled gas and pre-booked most of the world gas supplies to meet their winter requirements.

In Pakistan, ordinarily, nearly 40 % of national power requirements are met by gas and oil fired power producing plants. Among the various sources of power, cost-wise, hydropower electricity, contributing 25% of total generation, is the cheapest, followed by gas produced electricity. Power produced from fuel oil is the most expensive. Coal produces only a small portion of total power. Nuclear power provides 12.8% of total power, while solar and wind produce relatively smaller proportions of 9% and 4%, respectively.

A dilemma regarding gas prices persists arising from the insufficient deals made for future gas supplies when international prices had plummeted during early days of the Covid pandemic.

Due to the absence of sufficient long-term gas deals and the acute shortage caused by pre-bookings by major gas consumers, there is such an acute shortage of LNG on world markets that gas was not available to Pakistan in 2022-23 even at spot rates as high as $36 per MMBTU. The 15-year-long LNG agreement signed with Qatar in 2015 was @ $13 per MMBTU. Sadly, a former Prime Minister and a Finance Minister were sent to jail for purchases made at allegedly exorbitant rates for which no proof was ultimately forthcoming.

Paradoxically, it was Qatar once again to which resort was subsequently made for a gas deal by a regime that had taken criminal actions against previous gas deals that were cheapest in the world at the time.

Due to shortage of cheaper gas, Pakistan is being forced to use expensive furnace oil for generation and increasing electricity prices. It is anticipated that the electricity prices will further increase unless international oil prices fall, which appears improbable.

We may also brace ourselves to face serious gas shortages during the coming winters unless dramatic changes occur on the international market. The OPEC energy picture is also not likely to ease out in the foreseeable future.

Due to resource constraints and commitments made with the IMF, Pakistan may not be in a position to alleviate consumer difficulties on account of electricity and gas price hikes through subsidies. With depressed growth projections, there may not be required fiscal space. Contrarily, there may be a shrinkage in revenue targets. Nor will any expenditure savings be possible in the present tight situation to create budgetary space for relief on energy prices. One can hope against hope for some reduction in power losses. We may latch hopes onto chances of easing of world gas and oil prices but hopes alone can bring little relief to hard-pressed family budgets of the common man.

As a result we are finding electricity and gas prices increasing, leading to sharp public outcry. Due to shortage of cheaper gas, Pakistan is being forced to use expensive furnace oil which increases electricity prices. It is anticipated that the electricity prices will further increase during the coming months. In case world oil prices fall, some relief may appear.

The country is also likely to face acute gas shortages during the coming winters unless there are dramatic changes on the Ukraine and Gaza war fronts leading to greater availability of gas and energy at lower prices.

High power prices will adversely impact manufacturing and export sectors through enhanced costs. Due to capacity payment agreements with Independent Power Plants (IPPs), T&D losses and other reasons, circular debt has risen to nearly Rs1.7 trillion.

Rates of electricity supplied by Discoes versus solar power rates are highly discriminative against solar generation. Discoes supply power at around Rs76 PKWH whereas Discoes pay/adjust only up to Rs21-23 PKWH for solar energy supplied to power grid. A fairer cross-tariff structure is necessary to promote solar generation which holds opportunities for considerable accretion to cheaper available power.

Due to resource constraints and commitments made with the IMF, Pakistan will not be in a position to alleviate consumer difficulties on account of electricity price hikes. With depressed growth projections, there will not be any relief available from an expected revenue collection enhancement. Contrarily, there may be a shrinkage in revenue targets for the year. Nor will any expenditure savings be possible in the present tight situation to create fiscal space for relief on electricity prices.

We may latch hopes onto chances of easing of world gas and oil prices but hope alone is pitiable relief to hard-pressed family budgets of the common consumers.

***Courtesy: Published in The Express Tribune, July 5th, 2024.***

## GOVT DEBT SOARS TO RS67.8TR IN MAY

**By**

**Shahbaz Rana**

Average increase of Rs56b per day raises concerns over fiscal management

**ISLAMABAD: Despite a stable rupee, the federal government's debt rose sharply to Rs67.8 trillion in May, marking one of the most rapid increases in any month, with an average of Rs56 billion per day added to the debt pile. The State Bank of Pakistan (SBP) reported on Friday that the federal government's total debt, excluding liabilities and the International Monetary Fund (IMF) debt, increased by Rs1.73 trillion within one month. The stocks were Rs66.1 trillion by the end of April, according to the new debt bulletin.**

As a result, the government's debt reached Rs67.8 trillion by the end of May. Overall, Rs7 trillion were added to the debt stock during the first 11 months (July-May) of the last fiscal year, at an average of Rs21 billion per day. However, in May alone, the increase was Rs56 billion per day. Such abnormal increases were last witnessed during times of extreme currency fluctuations.

During the last fiscal year, the rupee gained against the US dollar, and it remained stable during the April-May period. Compared to June last year, the value of the rupee stabilised and even showed improvement in May. This stability helped mitigate the increase in external debt, combined with low credit ratings that hindered foreign commercial banks from extending new loans to Pakistan.

The rupee-dollar parity was Rs286.39 in June last year, which improved to Rs278.38 in May this year – a gain of Rs8 per dollar. As a result, the external federal government debt reduced from Rs22 trillion to Rs21.6 trillion over the past year due to the appreciation of the rupee against the US dollar.

The federal government's total domestic debt increased to Rs46.2 trillion, rising by Rs7.12 trillion within one month. This raises questions over the debt management of the finance ministry and its fiscal operations. The sudden spike in debt also indicates that the government's fiscal operations might have gone haywire. For the last fiscal year, the government had set the budget deficit target at Rs7.5 trillion, which is going to miss by a margin of around Rs1 trillion.

The Rs1.733 trillion increase in public debt in May alone suggests that the government has borrowed more than what was required to finance fiscal operations. Any financing over and above the budget deficit would cause an unnecessary addition to interest costs.

The increase was mainly in the government's long-term debt, which jumped from Rs32 trillion to Rs33.4 trillion – an addition of Rs1.4 trillion within one month. The short-term domestic debt increased by Rs356 billion within one month, according to the central bank. The government's long-term borrowings came at the highest rate of over 23%. It was not clear how much of the Rs1.4 trillion was on a fixed interest rate and how much was on a floating rate. Any borrowing at fixed interest rates over and above the budgetary needs might add undue burden on taxpayers' shoulders.

The growing debt burden has also pushed the cost of interest payments from Rs8.3 trillion in the last fiscal year to Rs9.8 trillion this year. Out of Rs1.7 trillion in additional taxes that the government has imposed in the budget, Rs1.5 trillion would go straight

to commercial banks. Despite repeated commitments to the IMF and the World Bank, the country's Debt Management Office is operating under capacity, and the Ministry of Finance seems disinclined to reinforce it.

The National Assembly has also allowed the federal government to borrow Rs33.8 trillion for the repayment of principal loans and debt servicing this year. Except for the Rs9.8 trillion cost of interest on debt, which is part of the federal budget, the rest of the amount will not be booked in the budget and will be directly borrowed from domestic and foreign markets to repay loans obtained in the past by successive governments.

Interest payments on domestic and foreign loans will consume roughly 52% of the proposed budget of Rs18.9 trillion for this fiscal year. The government will borrow Rs19.1 trillion to repay maturing domestic debt this fiscal year. The government is going to borrow another Rs8.5 trillion this fiscal year to finance the budget deficit. It is spending on subsidies, defence, development, and running the civil government through debt.

The government's policies to restrict the power sector circular debt through tariff increases have also failed. The Power Division on Friday informed the Cabinet Committee on Energy that the circular debt jumped to Rs2.655 trillion by the end of May, according to a press statement issued by the prime minister's office. The Rs2.655 trillion circular debt was Rs345 billion over and above the limit permissible by the IMF.

The government had last year increased electricity prices by around Rs8 per unit to stop the flow of the circular debt, which again remained out of control as of the end of May. It has again increased the electricity price by up to Rs7.12 per unit – a move that will likely backfire as in the last fiscal year.

***Courtesy: Published in The Express Tribune, July 6th, 2024.***

## TOXIC AIR TIGHTENS CHOKEHOLD ON PUNJAB

**By**

**Adnan Lodhi**

US consulate reports worsening pollution since 2019

**LAHORE: Lahore's residents endured 44 days of 'hazardous' air pollution during last year, revealed and Air Monitoring Report of the United States Consulate.**

The report shows that the number of annual days marked by levels of air pollution deemed hazardous for human health in the city increased from 24 to 44 during the past five years.

The frequency of days when then city records 'very unhealthy' air pollution has also increased. Lahorites spent 67 days in a 365-day year amidst an unhealthy air pollution level in addition to 44 in hazardous environmental conditions.

Hazardous Air Quality ratio is the worst stage in the monitoring index that spreads cancer and other diseases among citizens.

Environmentalists have warned that worsening of the situation due to lack of effective measures at mitigation could leave the city uninhabitable.

According to the report, air pollution in the city had worsened at an alarming rate during the past five years.

The findings cited in the Punjab State of the Environment Report launched recently showed that the city's residents faced 44 days of hazardous and 67 of unhealthy air pollution in 2023.

Lahore remained among the five most polluted cities of the world and the situation also forced the authorities to shut educational institutions in the province.

The Lahore High Court also took notice of the air pollution in the city and advised action against smoke-emitting vehicles. The provincial environment department also stepped up efforts to handle the situation following the instructions.

The US consulate's monitoring follows the global standards, classifying the air quality ratio into six categories of good, moderate, unhealthy for sensitive groups, unhealthy, very unhealthy and hazardous.

According to the air quality standards, 'hazardous' is the worst category, showing extreme air pollution that, according to medical and environmental experts, is dangerous for life.

The consulate's monitoring revealed that Lahore had witnessed 31 days of hazardous air quality in 2022, 35 each in 2021 and 2020, and 24 in 2019.

The number of days when the air quality was deemed very unhealthy was 67 in 2023, 74 in 2022, 49 in 2021, 47 in 2020 and 43 in 2019.

A senior officer of the Environment Protection Agency said the US consulate's report had shown that the number of good and moderate AQI days in a year in the city had decreased since 2019. The number of days with hazardous and very unhealthy pollution levels have increased.

The official said an improved air quality in 2020 was attributed to limited industrial and transportation activities during the COVID-19 pandemic.

He said the provincial environment department's data was based on the Punjab EPA's AQI categories with varying boundaries.

An environmentalist said almost half the year in the city is spent in an environment requiring caution and it had become evident that Lahore is facing a situation worse than most of the world.

He said the experts had been demanding that the Punjab government consult the stakeholders on a constructive policy to fight air pollution challenges and initiate steps that immediately provide relief to the citizens.

He said the increasing number of hazardous and unhealthy days every year proves a slide towards destruction and the health problems caused by the pollution are also on the rise.

The expert said the elderly and children would be at a severe risk if the situation was not improved and the air quality deteriorated.

"We have been the worst affected by climate change and are residing in a place that will technically not be fit for human life," he added.

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## TERRORISM THREATENING TRANSBOUNDARY WATERCOURSES

**By**

**Maham Naweed**

**The menace of terrorism looms over the international community, posing a major threat to the multilateral world order. Over the years, in an attempt to create a robust infrastructure to deal with this multifaceted threat, the international community has signed various specialised multilateral and bilateral agreements to enhance cooperation on the suppression of terrorism. However, the targets of terrorist threats are continuously evolving, which adds to the severity and complexity of the problem. One such target is water.**

Post 9/11, the world has seen a surge in the number of terrorist threats aimed at water resources and infrastructures. In light of water scarcity, this requires the immediate attention of the international community. The international character and complexity of the issue is further magnified by the presence of transboundary watercourses. This means that terrorist attacks on the water infrastructure in one country can have an impact on the quantity and quality of water in another country.

Global conflicts have shown that terrorists use water resources to threaten communities and weaken states. The attack on the Euphrates and Tigris river system, primarily shared between Turkey, Syria, Iraq and Iran, serves as an example. When the Islamic State (IS) seized control of several important dams in both Iraq and Syria, the terrorist outfit used its control over water as a weapon in a number of ways. IS's use of water indicated that weaponisation could be caused by too little or too much water. Terrorists can also impact the quality of water.

The legal issue is that as of now, there exists a gap in international law connecting terrorism and transboundary watercourses, with the result that water-related terrorism is not adequately addressed. The problem is multipronged. First, there is no agreed upon definition of terrorism in international law, which means the political and ideological connotations related to terrorism remain contested. Most of the terrorism related international agreements are specialised in nature focusing on issues such as hostage taking on aircraft, financing of terrorism, protection of nuclear material and safety of maritime navigation. Whereas some of these instruments make an attempt at defining terrorism, the lack of a clear definition of terrorism under international law remains a major issue. In the case of water-related terrorism, this impacts the classification of actions as terrorism.

Second, as of now, international water law does not contain any express provision dealing with the protection of a transboundary watercourse from terrorism. Moreover, there is no provision obligating riparian states to cooperate over combating water-related terrorism. With the increase in the amount of water-related terrorist incidents happening globally, international lawyers and academics can no longer shelf this issue or limit it to the confines of academic debates. The ideal situation would be the creation of a specialised treaty dealing with the protection of transboundary watercourses from terrorism.

The lack of consensus on a definition of terrorism is an indication of states' hardlining on polarising issues. Similarly, despite overwhelming support when signed in 1997, the ratification process of the UN Convention on the Law of the Non-Navigational Uses of International Watercourses has been slow. Hence, geopolitical limitations weigh against the signing of a specialised treaty.

A legal argument can be made that such a duty to cooperate should also extend to protecting the watercourse from the threat of terrorism and also to cooperate over the apprehension and investigation of crimes committed against a shared watercourse. Furthermore, the duty to cooperate includes the duty to notify.

Again, whereas this duty to notify has historically been triggered in cases of dam construction, a plausible argument can be made to notify riparian states, sharing watercourses, of an imminent terrorist threat, if one is uncovered in the course of ordinary due diligence. The use of existing international water law principles may not be the ideal solution to the issue at hand, but it offers the quickest and most easily accessible solution to a pressing international legal issue.

***Courtesy: Published in The Express Tribune, July 12th, 2024.***

## PAKISTAN SEEKS CHINA'S ENERGY DEBT RELIEF

**By**

**Shahbaz Rana**

PM urged Chinese leaders to form a working group to address $15 billion energy debt and $1.8 billion outstanding dues

**ISLAMABAD: Finance Minister Muhammad Aurangzeb's visit to China for talks to restructure the $15 billion energy debt has been rescheduled to the third week of this month due to other engagements of the Chinese authorities.**

In place of the finance minister, Planning Minister Ahsan Iqbal has taken the letters on behalf of Prime Minister Shehbaz Sharif to Beijing. The prime minister has requested the Chinese leadership to constitute a working group to resolve the issues related to $15 billion Chinese energy debt payments and clearance of $1.8 billion outstanding dues of the Chinese power plants.

"The Chinese leadership is busy with the third plenum till July 18th, so the visit is now being scheduled for the week after", said Finance Minister Muhammad Aurangzeb after the meeting of the National Assembly Standing Committee on Finance.

Earlier, Prime Minister Shehbaz Sharif had asked the minister to take a letter from him to the Chinese leadership with a request to reschedule the energy debt. The idea was that the finance minister would fly along with the planning minister as the premier's special envoy.

"On behalf of the Prime Minister, I am delivering the letters to the Chinese leadership during my ongoing visit," said Iqbal while talking to The Express Tribune. But he said that the finance minister would also visit once the Chinese leadership is free from the plenum meetings.

Iqbal had left for Beijing on Wednesday to participate in the Global Development Initiative (GDI) meetings. Aurangzeb could not accompany the planning minister as the Pakistani mission in Beijing could not secure the meetings with the Chinese leadership.

The Pakistani embassy in Beijing had advised that the finance minister should wait until the Chinese leadership gets free from its other scheduled business.

Last Saturday, the prime minister had said that the Minister for Finance will accompany the planning minister and will carry letters from the prime minister for the Chinese leadership on loan reprofiling and coal conversion of the Chinese power plants.

The erratic decision by the prime minister put the Pakistani embassy in Beijing in an awkward situation to try to secure the meetings in an emergency. Another cabinet member ruled out that the Chinese authorities have refused to entertain the finance minister.

China has set up 21 energy projects in Pakistan with a total cost of $21 billion, including about $5 billion in equity. The Chinese investors obtained loans for the projects at an interest rate equal to the London Interbank Offered Rate (Libor) plus 4.5%. Against the remaining Chinese energy debt of over $15 billion, payments by 2040 would total $16.6 billion, according to government sources.

The Pakistani proposal involves extending debt repayments from 10 to 15 years. This would reduce the outflow of foreign currency by about $550 million to $750 million per annum and decrease prices by Rs3 per unit.

According to the existing IPP deals, the current power tariff structure requires debt servicing repayments during the first 10 years, leading to a significant burden on consumers who are paying the interest and principal of these loans through higher tariffs. But due to the extended repayment period, the country will also have to make an extra $1.3 billion payment to China, sources said.

It is not clear what Pakistan is going to offer to China in return for securing debt restructuring. China's two biggest concerns are security of its national and clearance of $1.8 billion dues that Pakistan has not paid against the power that it purchased from around one-dozen Chinese power plants.

If China agrees to debt restructuring, the repayment period will be extended to 2040, including interest payments. According to Pakistani authorities, repayment would be $600 million less this year and can be reduced to just $1.63 billion after restructuring. For 2025, debt repayments would decrease from $2.1 billion to $1.55 billion—a benefit of $580 million, sources said. However, the upfront relief would result in more repayments from 2036 to 2040.

In April, the prime minister had ordered all imported coal-fired power plants, including three Chinese plants, to convert to local coal to save $800 million annually and reduce consumer rates by Rs3 per unit. At least five major imported coal-fired power plants with a total capacity of 5,940 megawatts are affected, including three Chinese-owned plants in Sahiwal, Port Qasim, and Hub, totaling 3,960 MW.

During Prime Minister Shehbaz Sharif's last month meeting with the President Xi Jinping, the Chinese leadership had indicated reviewing the possibility of using either the blend of local or imported coal or converting to the local coal.

Through these letters, Pakistan has requested China to find a win-win solution to the problems of Chinese energy debt repayments and the coal conversions.

***Courtesy: Published in The Express Tribune, July 12th, 2024.***

## PAKISTAN SET TO SURPASS INDONESIA

## APP

UN report projects peak population of 404m by 2092

**UNITED NATIONS: A key UN report has placed Pakistan, with a current population of over 245 million, among the countries expected to see population growth through 2054, potentially peaking in the second half of the century or later.**

According to projections in the UN's World Population Prospects 2024 report, Pakistan's population is anticipated to peak in 2092 at 404.68 million people. The report also indicates that Pakistan's population will surpass that of Indonesia in 2048, reaching 331.29 million by then.

Between 1998 and 2017, Pakistan experienced an average population growth rate of 2.40%, resulting in an annual increase of about 5.28 million people for a population exceeding 220 million.

The report highlights Pakistan's high birth rate of 22 births per 1,000 people. It points out that few women in Pakistan use any form of birth control, which contributes to the rapid population growth. This surge in population is likely to exert significant pressure on water and sanitation systems, create millions of unemployed people, and overwhelm health and education systems.

Since the year 1947, when the country became a sovereign state, the population of Pakistan has increased significantly, particularly because more and more people felt comfortable moving their families and businesses to the area, the report said.

Compared to the other countries in the region, the growth rate of Pakistan is about 2.1 percent higher, it said.

The report predicted that in about 35 years, if this growth continues, the population of Pakistan will eventually become double of what it was back in 2001. Judging from how the population has grown significantly over just ten years, this "doubled population" figure does not seem to be far off, it said.

The current growth rate in Pakistan is close to 2%, but this is expected to halve to less than 1% by the year 2050 – at which point it is predicted to cross the 300 million threshold.

The report also said that the global population reached nearly 8.2 billion by mid-2024 and is expected to grow by another two billion over the next 60 years, peaking at around 10.3 billion in the mid-2080s.

It will then fall to around 10.2 billion, which is 700 million lower than expected a decade ago. That's just one of the key findings revealed in the report published by the UN Thursday.

However, changes in global population are uneven and the demographic landscape is evolving, with rapid population growth in some places and rapid ageing in others, making reliable population data "more important than ever", said the UN sexual and reproductive health agency (UNFPA), heralding the report which is published to coincide with World Population Day. The report "must be used to reach and respond to the needs of those who have been left behind," the agency added.

Marking the international day, UN Secretary-General Antonio Guterres said it was key to accurately count everyone “because everyone counts.”

“Our rich human tapestry is only as strong as its weakest thread. When data and other systems work for those on the margins, they work for everyone. This is how we accelerate progress for all.”

To study this population data more closely, the 28th edition of World Population Prospects (WPP) published by the UN Department of Economic and Social Affairs (DESA) since 1951, provides the latest demographic data for 237 countries from 1950 to 2024 and projections up to the year 2100.

The WPP is crucial to monitor the Sustainable Development Goals, with about a quarter of the indicators relying on its data.

The world’s overall fertility rates are dropping, with women having one child fewer on average than they did around 1990.

In more than half of all countries and areas, the average number of live births per woman is below 2.1 — the level required for a population to maintain a constant size.

Meanwhile, nearly a fifth of all countries and areas, including China, Italy, South Korea and Spain, now have “ultra-low fertility”, with fewer than 1.4 live births per woman over a lifetime.

As of 2024, population size has peaked in 63 countries and areas, including China, Germany, Japan and the Russian Federation, and the total population of this group is projected to decline by 14 per cent over the next thirty years. The average age of the population of the world is also increasing. By the late 2070s, the number of persons 65 years or older is projected to surpass the number of persons under 18.

This is in part due to the overall increase in life expectancy and decrease in mortality rates over the past three decades. By the late 2050s, more than half of all global deaths will occur at age 80 or higher, a substantial increase from 17 per cent in 1995.

While the slow growth or decline of populations is occurring mainly in high-income countries, rapid population growth will occur in low-income and lower-middle-income countries.

Specifically, Angola, the Central African Republic, the Democratic Republic of Congo, Niger, and Somalia, very rapid growth is projected, with their total population doubling between 2024 and 2054.

This population growth will increase demand for resources, especially in sub-Saharan Africa and South Asia and, combined with poorly managed urbanisation and rising living standards, it will worsen environmental impacts.

Climate change, a major challenge, affects these countries the most, where many rely on agriculture – and food insecurity is prevalent.

In countries including India, Indonesia, Nigeria, Pakistan and the United States, population is also expected to increase through 2054 and could potentially peak in the second half of the century or later.

Central to population and development is the “recognition that women’s sexual and reproductive health and reproductive rights are cornerstones of sustainable development,” said Secretary-General Guterres.

Particularly in low-income countries, early pregnancies remain a challenge.

In 2024, 4.7 million babies, or about 3.5 per cent of the total worldwide, were born to mothers under the age of 18. Of these, some 340,000 were born to children under 15, with serious consequences for the health and well-being of both the young mothers and their children.

***Courtesy: Published in The Express Tribune, July 13th, 2024.***

## MOODY'S DOUBTS SUCCESS OF IMF LOAN

**By**

**Salman Siddiqui**

**KARACHI: Moody's Ratings anticipates that the International Monetary Fund (IMF) Executive Board will approve the $7 billion loan programme for Pakistan, but is doubtful about whether the country will complete the 37-month Extended Fund Facility (EFF), which includes tough structural reforms amid a politically weak government.**

In its commentary titled "Government of Pakistan – IMF's Staff-Level Agreement Improves Funding Prospects, but Ability to Sustain Reforms Key to Easing Liquidity Risks," the global rating agency noted that the IMF and Pakistani authorities reached a staff-level agreement (SLA) on a 37-month EFF of about $7 billion on July 12, 2024.

"If approved, 'which we expect is likely', the new IMF programme will improve Pakistan's (Caa3 stable) funding prospects. The programme will provide credible sources of financing from the IMF and catalyse funding from other bilateral and multilateral partners to meet Pakistan's external financing needs."

However, the agency highlighted that Pakistan's external position remains fragile, with high external financing requirements over the next three to five years. "The country is vulnerable to policy slippages. Weak governance and high social tensions can compound the government's ability to advance reforms, jeopardizing its ability to complete reviews under the IMF programme and unlock external financing."

According to an IMF report published in May, Pakistan's external financing needs are about $21 billion for fiscal 2025 (ending June 2025) and about $23 billion for fiscal 2026-27. Pakistan's foreign exchange reserves of $9.4 billion as of July 5, 2024, are well below its needs.

The new IMF EFF comes with conditions for far-reaching reforms, such as measures to broaden the tax base, remove exemptions, and make timely adjustments to energy tariffs to restore the energy sector's viability. Other measures include improving the management and privatization of state-owned enterprises, phasing out agricultural support prices and associated subsidies, advancing anti-corruption, governance, and transparency reforms, and gradually liberalizing trade policy.

Moody's stated that the government's ability to sustain reform implementation will be key to allowing Pakistan to continually unlock financing over the duration of the IMF programme, leading to a durable easing of government liquidity risks.

A resurgence of social tensions due to the high cost of living—which may increase because of higher taxes and future adjustments to energy tariffs—could weigh on reform implementation. Moreover, the coalition government may not have a sufficiently strong electoral mandate to continually implement difficult reforms.

It is noted that Pakistan has a long history of entering IMF loan programmes, including EFFs, but failing to complete most of them amid tough conditions and weak political capacity. The latest EFF, pending IMF Executive Board approval, is the 24th loan programme in Pakistan's 77-year history.

Muhammad Sohail, CEO of Topline Securities, noted in a short commentary that the current 37-month package worth $7 billion is the fourth EFF since 2001. Pakistan completed the first two EFFs during 2001-2004 and 2013-2016, which supported

positive economic growth. However, the country failed to complete the third EFF during 2019-2022 and suffered economically.

Topline Research expressed hope that Pakistan will comply with IMF conditions attached to the new EFF (2024-2027) and help achieve “moderate economic recovery” after several years of slowdown and high inflation.

Although there is no set date for IMF Executive Board consideration for the expected final approval of the programme for Pakistan, the research house said the board approval normally takes a couple of weeks after the SLA.

Topline Research also mentioned that the government is planning to augment the size of the package by including a Climate Facility in the first review of the new IMF programme. “We believe, if this happens, the minimum size of the climate facility would be 1 billion SDR, equivalent to $1.4 billion. This will be another boost to Pakistan’s external position,” Topline said.

The new programme aims to strengthen macroeconomic stability and set the path for resilient and inclusive growth.

Sana Tawfik, an economist at Arif Habib Limited, said in a video message that the new IMF loan programme would help strengthen the economic stability achieved during the nine-month short Standby Arrangement worth $3 billion completed in April 2024. The new programme will ensure continuity in the repayment of external debt and provide the cover to ramp up economic activities during the 37-month course of the programme, she said.

***Courtesy: Published in The Express Tribune, July 17th, 2024.***

## DATE PALM CULTIVATION IN THAR PROVES FRUITFUL

Karachi youth plant 500 trees, use solar-powered tubewells for irrigation

**KARACHI: The efforts of a group of young people of Karachi to cultivate Ajwa, Mazfati and Aseel date palms in the sand swept Tharparkar district have proved fruitful.**

As many as 200 out of 500 trees planted by Dua Foundation in various areas under the project, started in 2018, have started bearing fruit.

For the prosperity of the local farmers of Tharparkar, the youth from Karachi cultivated different types of date palms in desert, and used underground water for irrigation, said Dua Foundation Chairman Amir Khan.

The organisation used the barren land of farmers to plant the trees and also arranged irrigation in the arid and barren area.

He said the foundation provided free solar-powered tubewells to irrigate the lands of people who could not afford it.

The success of the experiment could lead to a revolution in agriculture in Thar desert where palm trees are not found, Khan said.

About six years ago, the experimental cultivation of dates was started by the social organisation of Karachi in Thar.

Palm trees brought from Punjab, Khairpur and Dera Ismail Khan were planted in different tehsils of Thar. The project also included consultation and guidance from the Pakistan Agriculture Research Council. Fruits on palm trees have proved to be a ray of hope for the malnourished people of Thar. These palm trees will not only be a source of employment for the poor people of Thar but will also help in improving the health of their families.

Under the project, these trees were planted free of charge on the barren lands of poor people of Thar. At the same time training was also provided to them. With the income from date palms planted in Diplo, Khloi and Dahli tehsils, the poor will not only be financially independent, but their standard of living will also be elevated.

More than 60 agro-farms have been established by the foundation in all Thar tehsils, out of which date palm trees were planted experimentally on many farms.

Under the auspices of Dua Foundation, a social organisation of Karachi, a ceremony was organised in this regard in Thar tehsil Kaloi, which was addressed by agricultural experts.

Speaking on the occasion they said that the experiment of palm cultivation was not successful in Tharparkar before but with continuous hard work and with the belssings of Allah, not only palm trees flourished but also they produced the sweet fruit.

Chairman of the Foundation, Amir Khan said that the land of Thar is very fertile.

***Courtesy: Published in The Express Tribune, July 17th, 2024.***

## FITCH SEEKS DATA AMID UNCERTAINTY

**By**

**Shahbaz Rana**

Aurangzeb briefs agency on economy; no discussion on predicted govt ouster

**ISLAMABAD: Fitch on Monday sought additional data from Pakistan regarding its gross external financing needs for the current fiscal year to decide whether to maintain the current high-risk credit rating or improve it in light of a new deal with the International Monetary Fund (IMF).**

The agency's representatives held a virtual meeting with Pakistan's Finance Minister Muhammad Aurangzeb shortly after issuing a politically sensitive report. However, the meeting did not address the firm's prediction about the potential ouster of Prime Minister Shehbaz Sharif's government within the next 12 to 18 months.

According to finance ministry officials, Fitch asked Pakistani authorities for details on total external financing requirements, plans to issue sovereign bonds, and raising debt from foreign commercial banks. The agency also requested more information about the country's energy sector, which remains in poor condition despite multiple electricity price increases burdening consumers.

In its last review, Fitch noted that Pakistan's external risks were easing but remained significantly high, retaining a 'CCC' rating that reflected high external funding risks amid substantial medium-term financing requirements despite some stabilisation and the successful completion of Pakistan's Stand-by Arrangement (SBA) with the IMF.

The government hoped for an upward rating revision due to the success of the last programme and a new $7 billion deal for 37 months. Fitch also sought clarifications about the budget numbers and domestic debt financing.

An official handout by the finance ministry stated that Muhammad Aurangzeb provided an extensive update on Pakistan's current economic landscape, starting with the successful completion of the 9-month SBA with the IMF. The minister emphasised the positive impact of the last IMF programme on the country's macroeconomic indicators.

Aurangzeb reported that Pakistan's foreign exchange reserves reached $9.4 billion, the stock exchange performed well, and inflation decreased to 12.6% in June 2024. He also noted a 7.7% rise in foreign remittances and a substantial 30% increase in tax collection during FY2024 compared to FY2023, with over 150,000 retailers registering as first-time taxpayers and IT exports exceeding $3 billion.

The federal minister informed the rating agency about multilateral institutions' confidence in financing Pakistan's projects and briefed them about Pakistan's Staff-Level Agreement (SLA) finalised in July 2024 with the IMF for a new medium-term programme aimed at bolstering Pakistan's homegrown economic reform agenda.

Aurangzeb outlined the new programme's goals, including increasing revenues by 1.5% of GDP in FY2025 and by 3% over the next three years, and achieving a primary surplus of 1% of GDP for FY2025. The government has set an ambitious tax target of nearly Rs13 trillion in the budget.

He reiterated the government's commitment to improving the tax-to-GDP ratio as part of ongoing fiscal consolidation measures. The discussions also covered ongoing reforms in the energy sector and state-owned enterprises, including privatisation and

rightsizing of federal government entities to streamline operations and improve governance, aid the finance ministry.

Fitch representatives appreciated the ambitious targets and fiscal measures adopted by the government of Pakistan and acknowledged the improvement in economic indicators, according to the finance ministry.

However, last week, BMI Fitch Solutions highlighted concerns about the sustainability of Pakistan's external debt due to the depreciation of the Pakistani rupee in 2022 and 2023. Despite rolling over significant debt payments in mid-2023, the underlying problem remains unaddressed.

"We forecast that Pakistani policymakers and their international partners will succeed in avoiding an acute debt crisis, but we think the country's debt levels will remain elevated over the next 10 years," stated BMI.

"Between 2023/24 and 2032/33, we expect growth in the country to average just 3.5%, compared to 5.4% in emerging markets," noted the BMI report. This comparatively poor performance will see Pakistan's GDP per capita fall further behind India's. Whereas Pakistan's GDP per capita was 78% of India's in 2019, this ratio is expected to drop to 51% by 2032, it added.

BMI also commented on Pakistan's political system and the legal battles faced by Imran Khan. "Despite several successful legal appeals, opposition leader Imran Khan will remain imprisoned for the foreseeable future. We expect the PML(N)-led government will remain in power over the next 18 months and will succeed in implementing IMF-mandated fiscal reforms."

The report noted that the current political administration, lacking popular support, faces the daunting challenge of managing an economy recovering from the 2022-23 crises while addressing fragile security concerns. "Further protests by Khan's supporters—many of whom believe their party has been targeted by Pakistan's establishment—are likely," according to BMI.

***Courtesy: Published in The Express Tribune, July 23rd, 2024.***

## DEBT SOARS TO RECORD RS74.6 TRILLION

**By**

**Shahbaz Rana**

Finance ministry report predicts major risks from external shocks

**ISLAMABAD: As Pakistan’s public and guaranteed debt has surged to a record Rs74.6 trillion by the end of June, a new report by the Finance Ministry assesses that in case of any new macroeconomic and fiscal shock the debt and financing needs would jump to unsustainable levels”.**

The Ministry of Finance's Debt Sustainability Analysis report for 2025-27 reveals that due to the high level of debt burden and the consequent gross financing requirements, Pakistan remains exposed to various debt sustainability-related risks.

"The debt profile is sustainable over the medium, however, faces significant risks from external shocks and structural vulnerabilities, particularly due to a high proportion of external and floating-rate domestic debt," shows the report.

The report details that Pakistan's total public and publicly guaranteed debt has risen substantially, standing at Rs74.6 trillion at the end of June 2024, according to the finance ministry. During the past fiscal year, the public debt burden increased by Rs8.2 trillion, or 12.3%, equating to 70.5% of the GDP. According to the Debt Limitation Act, the debt-to-GDP ratio should have been below 57.5%.

This higher-than-statutory debt limit indicates that Pakistan's debt burden is unsustainable. However, the International Monetary Fund (IMF) continues to declare it sustainable to avoid the need for immediate domestic and foreign debt restructuring.

The finance ministry report further states that the significant increase in public debt was primarily due to the financing of the federal fiscal deficit, with interest expenses being a major component. In the baseline scenario, the finance ministry projects that the debt-to-GDP ratio will follow a downward trajectory from FY2025 to FY2027, ranging from 68.5% to 66.4%. However, this optimistic outlook is threatened by the potential for a combination of fiscal and macroeconomic shocks, which could push the ratio above 70%, jeopardising debt sustainability.

In a combined macro-fiscal shock scenario, the debt-to-GDP ratio could exceed the 70% threshold, risking debt sustainability, according to the finance ministry. In addition, a macro-fiscal shock could cause the debt-to-GDP ratio to reach 75%, which is 8.6% above the baseline scenario.

As a result, the total financing requirements of the Pakistani government would range around 22.6% of the GDP□3.2% higher than the baseline assumption. For a developing country like Pakistan, financing requirements of 15% of the GDP are considered manageable.

The finance ministry warns that lower-than-expected economic growth, a rise in the primary deficit, an increase in real interest rates, a surge in contingent liabilities, and exchange rate depreciation could significantly increase public debt and gross financing needs, both as a ratio of GDP, over the medium term.

The report also notes that Pakistan's external debt is mostly obtained from concessional bilateral and multilateral sources. Although the maturity structure is expected to extend over the three-year horizon, the growing share of short-term debt

in recent years poses risks to debt sustainability due to high refinancing risk, further increasing gross financing needs.

Within the external debt portfolio, fixed-rate debt accounts for 63% of total external debt, while floating-rate debt accounts for 37%. Meanwhile, domestic debt, which constituted 66.2% of the total public debt by the end of June, largely has long-term maturity. However, the large share of floating-rate debt within domestic debt poses a significant interest rate risk, according to the finance ministry. Fixed-rate debt accounts for 26% of total domestic debt, while floating-rate debt accounts for 74%.

**Baseline scenario**

In the baseline scenario, the finance ministry assumes that the economy will grow by 3.6% in FY2025. Inflation may average 12% for FY2025 before reaching single digits in FY2026. The exchange rate stabilised in FY2024 against the backdrop of a favorable current account balance and is projected to remain stable over the medium term. In alignment with the government's fiscal consolidation efforts, the federal primary balance is projected to improve significantly during FY2025-27.

**Shock scenario**

The finance ministry states that due to limited fiscal space, a sudden shift in the primary balance is not beyond expectation. If a shock occurs in the primary balance, increasing the primary deficit close to historical levels, the debt-to-GDP ratio will exceed the 70% benchmark, risking debt sustainability.

The finance ministry adds that if economic growth remains at 2.6% in this fiscal year, the debt-to-GDP ratio will surpass the 70% benchmark and may reach 70.6% in fiscal year 2027. The adverse GDP growth shock will persistently keep the debt-to-GDP ratio at 70% or higher over the medium term.

The large share of floating-rate debt within domestic debt also makes domestic debt vulnerable to nominal interest rate shocks. With low foreign exchange reserves and scarce market financing, nominal interest rates could adversely impact debt-to-GDP ratios.

The high share of external debt poses additional risks to debt sustainability through exchange rate depreciation. Although Pakistan's capacity to repay its external debt obligations remains adequate, it is subject to risks from inadequate export receipts, rising imports, and a deteriorating current account balance, which may exert pressure on the exchange rate, said the finance ministry.

***Courtesy: Published in The Express Tribune, August 10th, 2024.***

## GOVT APPROVES RS60B RELIEF PACKAGE

**By**

**Shahbaz Rana**

ECC also grants industry status to the warehousing sector after bureaucratic shuffle

**ISLAMABAD: The government on Thursday approved a Rs60 billion relief package to provide five essential goods to poorer households at subsidised rates, a 71% increase from the previous allocation due to a significant rise in prices over the past year.**

The decision was made by the Economic Coordination Committee (ECC) of the Cabinet, led by Finance Minister Muhammad Aurangzeb. In addition to the relief package, the ECC also approved industry status for the warehousing and logistics sector. This decision followed the transfer of the Secretary of Industries, as the previous secretary had opposed the proposal due to constitutional and legal challenges.

The Cabinet Committee approved the continuation of the Prime Minister's Relief Package for fiscal year 2024-25 through the Utility Stores Corporation, with revised prices and subsidies. According to a brief statement issued by the Ministry of Finance after the ECC meeting, the government has already allocated funds in the budget, so no new money will be required to finance the package. Of the Rs60 billion, Rs10 billion will be allocated to fund the Ramazan Relief Package.

Additionally, Rs1 billion from the Rs60 billion will go to the Federal Board of Revenue (FBR) to cover the tax on the subsidy. In the previous fiscal year, the government had allocated Rs35 billion to subsidise five essential goods through the government-owned chain of utility stores. The increase to Rs60 billion is due to the significant rise in the prices of wheat flour, rice, sugar, ghee, and pulses.

Last year, the government provided an average targeted subsidy of Rs2,734 per household through the utility stores. This amount has now increased by one-fourth, raising the per-household subsidy to Rs3,650, according to the ECC's decision.

Each household identified through the Benazir Income Support Programme will receive a subsidy of Rs1,700 per 20kg bag of wheat flour. Additionally, a subsidy of Rs50 per kg will be provided for sugar, Rs100 per kg for ghee, Rs50 per kg for pulses, and Rs100 per kg for low-quality rice through the utility stores.

Average inflation during the last fiscal year remained over 23%, marking another year of high double-digit inflation. While the government has been addressing the needs of a small portion of the population through subsidised essential items, the remaining population continues to face market-driven prices.

The finance ministry further stated that the ECC approved the Ministry of Industries & Production's request to declare the Warehousing and Logistics Sector as an industry. Businesses gaining industry status are exempted from minimum equity requirements and can borrow from the central bank in excess of their capital. The warehousing and logistics sector will now be eligible for tariff concessions on machinery imports, paying only 5% customs duty and zero sales tax. The industry will also receive new concessions on industrial and gas charges.

The Board of Investment conditionally supported the move to grant industry status to the warehousing business, with the caveat that the consent of the Council of Common Interest be sought in light of the 18th constitutional amendment.

In April, the prime minister, during his visit to the Karachi Chamber, had declared the intent to grant industry status to the warehousing sector. However, federal bureaucracy was initially reluctant to move forward, arguing that under the constitution, industry is a provincial matter. The prime minister then transferred the Secretary of Industries and brought in a new secretary to ensure his orders were implemented.

On Thursday, the acting Secretary of Finance also expressed reservations about granting industry status and suggested first seeking the endorsement of the Law Division. However, the ECC rejected her proposal and approved the summary.

Provincial governments have endorsed the proposal, though the Sindh government provided conditional support, stating that industry status should be granted only if it aligns with existing rules and regulations.

***Courtesy: Published in The Express Tribune, August 16th, 2024.***

## PARAGLIDERS FLY OVER SALT RANGE TO THROW SEED BOMBS

**By**

**Nabeel Anwar Dhakku**

**CHAKWAL:** In a first of its kind, the Chakwal Forest Division, while making the most of paragliding, has managed to disperse 20,000 seed balls with the help of paragliders who carried out the seed bombing at Aara Forest Reserve on August 13 and 14.

“Although throwing seed balls is a popular practice in plantations, throwing seed balls through paragliders was the maiden experience in the country,” Divisional Forest Officer Sadheer Ahmed Mughal told Dawn.

The drive was inaugurated by the Chakwal deputy commissioner and as many as fifteen paragliders from the Pakistan Hand Gliding and Paragliding Association (PHPA) took part in it.

Chakwal has 167,000 acres of forest area and a major chunk of this woodland falls in the jagged Salt Range, which also remained in the headlines for multiple forest fires over the past summer.

“As the most mountainous area is inaccessible for humans, we opted for paragliding to throw seed balls,” Mr Mughal said while talking about the novelty of the idea. He said the germination rate of seed balls was 80pc, which made them ideal for the purpose. “Due to higher germination rate, seed balls are the best method to grow the forest cover,” he said, adding that 20,000 seed balls were prepared by the workers of the Forest Department using soil, compost and coal.

“Seed can be stored in seed balls for a longer time. If it does not rain for a certain period, the seeds preserved in these balls do not die,” he explained. The 20,000 seed bombs contained 100,000 seeds – five seeds of five different plants in each ball.

The forest official explained that the seed balls contained seeds of Kikar (acacia nilotica), Phulahi (acacia modesta), Shareen (albizia lebbeck), Sanatha (dodonaea visosa) and Amaltas (cassia fistula or golden shower tree).

“Kikar, Phulahi, Santha and Shareen are the natives of the area and are prevalent in the Salt Range whereas we used Amaltas for the first time as an experiment. “If the experiment of Amaltas turns out to be successful, these plants would add to the mesmerising beauty of the Salt Range due to their golden flowers,” he added.

The paragliders who took part in the initiative said they were proud to be a part of this unique plantation drive. They added that paragliding was their passion and they would use this passion to turn the country greener by throwing seed balls.

Meanwhile, Mr Mughal said that as many as 175,000 saplings of different plants had been planted in Chakwal during the ongoing season. “This is the official figure which does not include the saplings planted by the private sectors,” he said, claiming that the public was participating in the ongoing plantation drive for the first time.

***Courtesy: Published in Dawn, August 18th, 2024***

## HOW PAKISTAN CAN TRANSFORM ITS AGRICULTURAL SECTOR

**By**

Daud Khan & Ghasharib Shoukat

One of the most urgent issues facing Pakistan's agriculture is the need for reform in land ownership, land market

**In 2023, amidst global economic challenges, Pakistan's agriculture sector emerged as an engine of growth, expanding by 6.5% and driving the country's modest GDP increase of 2.38%.**

The government has set a target growth rate of 3.6% for the coming year. While manufacturing and services, particularly IT, are often highlighted for their growth potential, the agricultural sector's ability to reduce poverty and boost exports should not be overlooked.

With new strategies and policies being formulated with the help of specialised international experts such as Professor Decron from Oxford University, it is crucial that the agricultural sector receives top priority in these plans.

One of the most urgent issues facing Pakistan's agriculture is the need for reform in land ownership and the land market. The best and most productive agricultural land is predominantly held by large farmers who are not focused on maximising yields or production. Many of these landowners are absentee landlords, living far from their properties, and leaving management in the hands of farm managers whose primary role is to extract rents from tenants rather than increase agricultural productivity.

This situation is further compounded by the reluctance of large landowners to sell or lease their land to smaller, more efficient farmers or entrepreneurs eager to invest in agriculture. Even when land is put on sale, it is often at prices out of line with potential earnings.

The discrepancy between land prices and earnings is not just an economic issue but a political one. Land ownership in Pakistan is tied to political power and access to government spending. In areas close to cities or major transport arteries, land also offers opportunities for conversion into residential colonies.

To correct these imbalances, the government must limit or eliminate programmes that disproportionately benefit large landholders, such as the wheat procurement program and blanket fertiliser subsidies. Additionally, revising the tax-free status of agriculture to align with income taxes in other sectors is essential. Complementary measures, such as banning the conversion of agricultural land into residential schemes and further streamlining and computerising the processes for land transfer, sale and leasing are also crucial.

Raising production and productivity in agriculture is not just about increasing quantities but about maximising the revenue generated from land and water resources. A prime example is the production of sugar - a crop that consumes vast amounts of land and water but remains viable in Pakistan only due to government protection. By removing this protection and allowing free imports of sugar, resources could be redirected towards more profitable crops like rice, fruits and vegetables, which offer higher incomes and greater export potential.

Another critical area of reform is the availability of high-quality seeds and genetic material for livestock. The government should incentivise local seed production, but

also liberalise the import of hybrid seeds and GMOs, which have the potential to increase yields by 30-50%. Furthermore, expanding the availability of land to commercial and corporate farming enterprises, particularly in regions where climate change and shifting rainfall patterns make cultivation viable, would help boost the production of essential crops like wheat.

Another priority should be the downsizing or abolition of ineffective government institutions at both the federal and provincial levels. At the federal level, this could include institutions tasked with policy and strategy formulation that have produced few worthwhile documents or those responsible for coordinating and managing research efforts but rarely hold meaningful meetings with provinces and the private sector. At the provincial level, departments of extension are prime examples. Often staffed by tens of thousands of workers, many of these departments are filled with "ghost workers" who only show up to collect their salaries. Even when these workers conduct field visits, farmers often ignore their advice in favor of guidance from input sellers or traders.

The funds saved by abolishing such ineffective institutions should be redirected to targeted programs that support dynamic production systems. An example of this is the spontaneous production clusters that have emerged across the country for dates, citrus, bananas, and sesame. These clusters should receive support in adopting new technologies and best practices from around the world. Another high-priority initiative would be to encourage efficiency and innovation by supporting the growing number of agro-tech companies across Pakistan.

Strengthening the Ministry of National Food Security and Research (MNFSR) is another critical action area. Despite agriculture being a provincial subject, the MNFSR has a crucial role, particularly in managing imports and exports, including wheat. Recent crises in the wheat market have highlighted the Ministry's limited capacity, which has had dire consequences for domestic producers and consumers. Strengthening this Ministry would ensure better management of critical agricultural resources and more stable markets.

Pakistan's agricultural sector holds enormous growth potential but is currently hampered by inefficiencies, an outdated product mix, and high losses during transport, storage, and marketing. However, both domestic and international technologies are available that could quickly improve productivity.

Relaunching agriculture in Pakistan does not require more government spending but smarter spending. Most existing government projects and programmes in the agricultural sector are ineffective and wasteful and should be eliminated. Instead, the government should focus on creating an enabling policy environment that encourages private sector investment, with its role limited to regulation and the provision of public goods such as new technologies.

For Pakistan to unlock its agricultural potential and ensure economic prosperity, the government must act swiftly on these reforms. Stakeholders from all sectors should collaborate to drive these changes forward. Now is the time to secure a sustainable agricultural future for Pakistan.

***Courtesy: Published in The Express Tribune, August 28th, 2024.***

## SQUANDERING AWAY OUR MOST PRECIOUS RESOURCE

**By**

**S M Ali**

Pakistan has been exploiting its groundwater sources with reckless abandon.

**Pakistan was never great at managing its natural resources, especially its freshwater, but growing population pressures and the need to contend with climate change have made it an existential imperative to pay more attention to this issue.**

Nature has been kind to Pakistan. The country enjoys access to the three major rivers of the mighty Indus, and the country is home to more than 7,000 glaciers, the highest number of such natural freshwater reservoirs anywhere other than the polar regions. These glaciers have been providing a perpetual source of water for the country, which alongside rainwater, feed the mighty rivers which traverse Pakistan, before pouring into the Arabian Sea. However, rising temperatures due to global warming have begun to cause an alarming level of glacial melt. In the short term, glacial melts lead to the creation of glacial lakes, which can burst when more melted water keeps gushing into them. Melting glaciers also increase the amount of water in the rivers which, coinciding with heavy rainfalls, causes flooding further afield. In the longer term, the reduction in the size of these glaciers will deplete water availability within major rivers on which the lives and livelihoods of multitudes of people depend.

Rather than thinking about water conservation and improving water efficiency, Pakistan has been wasting its precious freshwater resources using wasteful flood irrigation, and due to badly maintained irrigation systems which also cause massive water losses. Over 90 per cent of the country's freshwater is diverted to agriculture, where a significant proportion of it is lost due to inadequate water management, and due to the producing of water-thirsty crops like sugarcane.

Besides using irrigation systems which tap the rivers flowing out of glaciers, Pakistan has also been exploiting its groundwater sources with reckless abandon. Now our policymakers are keen to entice the Gulf states and China into investing in agriculture in the desperate bid to earn foreign exchange, which threatens to further deplete underground water sources.

Meanwhile, marginalised farmers have been experiencing major water stress, especially those whose land is located at the tail end of watercourses, where water often run out long due to inefficient water use by those more affluent, who occupy land at the head of watercourses.

Conversely, ordinary citizens across many rural areas and in unregulated and poorer urban neighborhoods don't have enough water to meet their household needs. Badly maintained water lines are often located perilously close to sewage systems, and there have been repeated reports of drinking water mixing with sanitation. Sporadic water tests in major cities have revealed unacceptable levels of faecal matter and heavy metals in water meant for human consumption. It is thus not surprising that water-borne diseases are a major cause of mortality within the country, and they lead to repeated bouts of sickness for adults, which then deplete already meager average household incomes, and cause a loss of productivity.

Women and girls bear the brunt of water scarcity, as the responsibility of fetching water for homes is usually a task relegated to females. The stubborn gender disparity in

education, especially when girls become a little older, has also been linked to this onerous responsibility placed on girls to either help their mothers fetch water, or else, to stay at home to look after younger siblings while the mother is out getting water.

Pakistan now has a plethora of policies and plans to ensure equitable water access to all citizens. What we still need is real action which can alleviate the water stress of our smaller farmers and which can provide reliable, convenient and safe sources of water for meeting the daily needs of all households, especially those who cannot afford the luxury of boring their own tube-wells, purchasing water pumps, using filters or purchasing mineral water on a regular basis.

***Courtesy: Published in The Express Tribune, September 27th, 2024.***

## OBSTACLES TO CLIMATE ACTIVISM IN PAKISTAN

**By**

**Mirza Mujtaba Baig**

The environment of fear in Pakistan, particularly in Karachi, is a major obstacle to climate activism.

There is no disagreement that Pakistan is one of the top five most vulnerable countries to climate change, despite its minimal contribution of 0.9% to global GHG emissions. Yet, few question how the country's annual GHG emissions are calculated given the lack of expertise in this field within Pakistan. Moreover, there is little discussion about whether Pakistan's vulnerability is due to its preparedness or lack thereof. These questions often remain unanswered or are deemed insignificant.

A similar situation was observed in the early 1990s when few people understood environmental pollution, and most considered garbage collection to be the sole responsibility of environmental regulators, which were still in their infancy at the time. However, due to pressure from global importers, export-based industries gradually began to comply with environmental laws to maintain their market share. Additionally, the growing green movement in the media and civil society led local industries to hire environmental consultants to ensure compliance and avoid legal action. While many of these efforts were superficial, the media played a crucial role in raising public awareness about the benefits of a clean environment.

Today, climate change is occurring at a rapid pace, yet institutional responses have been slow. Even the establishment of climate change institutions has been delayed, with a fully-fledged climate change authority being established only recently, seven years after the passage of the first climate change act. While climate change policies and adaptation plans exist at both federal and provincial levels, ground-level implementation remains minimal. Unlike the environmental movement of the past, there is limited awareness and engagement on climate change within civil society beyond superficial support. A few NGOs are working to address the issue, but their outreach is hampered by resource constraints.

The media, while trying its best to highlight the issue, is heavily focused on covering climate disasters, which have become increasingly frequent. This focus leaves little room for discussing climate change mitigation and adaptation strategies. Additionally, the lack of progress at the government level, beyond a few selected projects under Nationally Determined Contributions, limits the media's ability to report on solutions. These projects are primarily focused on demonstrating compliance with the Paris Agreement and securing climate finance.

A significant obstacle to climate activism in Pakistan is the lack of knowledge within civil society about climate change, its causes and its impacts. While people may understand the basic causes and effects, they often rely on climate change experts, who are limited in number and may be reluctant to speak out due to job constraints. This places a heavy burden on a small group of climate activists with expertise in the field.

In Karachi, a group of climate activists has been organising climate marches, but these events have struggled to attract large crowds. Another group is working to mobilise communities to address issues like costly electricity, load-shedding and heatwaves through a transition to renewable energy. However, these efforts face resistance from

communities that are more concerned with other pressing issues and are less receptive to climate change solutions.

While the Sindh Forest Department's initiative to generate carbon credits through nature-based solutions is commendable, it highlights the challenges of ensuring climate justice at the community level. Despite the project's significant revenue, the surrounding communities have not received a commensurate share, which constitutes a clear violation of climate justice principles. Although the project proponent claims to have undertaken community development activities, the scale of these efforts is disproportionate to the total earnings. A more engaged and active community, driven by climate activism, could have helped to prevent such disparities.

At the government level, there is a lack of support for fostering climate activism within communities. Instead, government-selected individuals are often provided with climate training to create a false impression of preparedness for collective action against climate change. A small group of climate activists in the city centre has started offering free training, but their efforts have received minimal attention due to the presence of numerous other groups that not only provide training but also pay participants. These paid training programmes attract individuals primarily interested in earning money rather than genuinely contributing to climate action.

Furthermore, unlike other sectors where anyone can contribute to community development, working in the climate sector requires a basic understanding of science to comprehend the relationship between GHG emissions, heat trapping and global warming. Additionally, political awareness is necessary to connect climate issues with broader political challenges, as institutional change requires the involvement of legislators.

In Western countries, the focus has shifted from climate activism to climate actionism, which involves working on the ground to address climate change. In Pakistan, however, climate activism is often limited to criticising the fossil fuel industry and government inaction. A recent campaign by a Karachi-based climate NGO to greenify the city's sole power generation company has faced backlash, highlighting the shortsightedness of many communities and their reluctance to engage in climate action.

The environment of fear in Pakistan, particularly in Karachi, is a major obstacle to climate activism. People are afraid of being labeled as traitors or facing legal action if they speak out for their climate rights. They may not realise that climate activism is essential for climate adaptation and that the city needs a large number of activists to work alongside rescue workers to mitigate the impacts of climate disasters. Without collective action, Pakistan will continue to suffer the consequences of climate change.

To effectively implement climate change mitigation and adaptation measures, the government must prioritise genuine programmes for community mobilisation. These initiatives should not be limited to bureaucratic paperwork but should actively engage with communities. To achieve this, the government should collaborate with genuine NGOs and community groups to promote climate activism and create a second tier of workforce capable of responding to climate crises. Relying solely on government servants may result in administrative efficiency but often falls short in addressing on-the-ground challenges. In such situations, the burden of protecting lives and property may fall disproportionately on a few philanthropic organizations.

***Courtesy: Published in The Express Tribune, October 1st, 2024.***

## US PUSHES FOR SPECIAL CREDITOR STATUS

**By**

**Shahbaz Rana**

Considers lending $1b to Pakistan for Reko Diq project; Islamabad remains hesitant

**ISLAMABAD: The United States on Thursday once again sought preferred creditor status for its Export-Import Bank (Exim), which is looking to lend approximately $1 billion to Pakistan's Reko Diq gold and copper mining project. However, Islamabad remains hesitant to grant such special status to a sovereign financial institution.**

The issue was raised during a meeting between US Ambassador to Pakistan Donald Blome and Finance Minister Muhammad Aurangzeb. According to government officials, Blome discussed the matter with Aurangzeb at the Finance Division. The finance minister assured the US envoy that Pakistan was reviewing the request, officials added. This is not the first time the US ambassador has raised the issue of preferred creditor status in recent months.

The meeting between the US envoy and Pakistan's finance minister occurred just two days before Aurangzeb's scheduled departure to Washington, where he is set to attend the annual meetings of the International Monetary Fund (IMF) and the World Bank. During his trip, the finance minister is also expected to meet with junior officials from the US State Department, US Treasury, and the US Department of Energy.

The Exim Bank of the United States, a sovereign export credit agency of the US government, has shown keen interest in financing the Reko Diq project, proposing a loan ranging from $1 billion to $1.5 billion. However, the Biden administration is seeking preferred creditor status due to the project's overall high credit risk.

While the updated feasibility study for Reko Diq is still pending, the project's total cost is estimated to be between $6 billion and $6.5 billion, with approximately $3.2 billion needed for debt financing. According to a handout from the finance ministry following the meeting, "matters of mutual interest and bilateral cooperation were discussed."

Pakistani authorities remain cautious about extending preferred creditor status to a bilateral lender as doing so might prompt China and other nations to demand the same treatment. The authorities were of the view that preferred creditor status was only meant for multilateral lenders like the World Bank.

In addition to the US Exim Bank, other major foreign lenders have expressed interest in financing the Reko Diq project. The World Bank's International Finance Corporation is considering a $650 million loan, while the Asian Development Bank is interested in providing $400 million and the Islamic Development Bank is looking to provide about $100 million. Other countries, including Canada offering $500 million, Japan considering $500 million, Germany looking at giving $300 million, South Korea considering $400 million, and Australia looking at about $200 million, have also shown willingness to offer significant financial support for the project.

The debt financing offers have exceeded requirements due to the project's immense potential. The US Exim Bank's loan would primarily be used for procuring earth-moving machinery for the mining operation.

The Reko Diq project is currently owned 50% by Barrick Gold, 25% by three federal government entities, and 25% by the provincial government of Balochistan. Barrick

Gold is in the process of updating the project's feasibility studies, which are expected to be completed by December 2024. The first phase of production is anticipated by 2028, and the mine is projected to have a lifespan of at least 40 years, with a combined processing capacity of 80 million tonnes per annum.

Saudi Arabia has also expressed interest in the project, offering to purchase a 15% stake and provide a $150 million grant to develop infrastructure around the mining area. However, Pakistan has not yet accepted this offer, given the high potential of the project and the expected rise in global gold and copper prices.

Once commercial operations begin at Reko Diq, the government hopes to develop adjacent mining blocks with joint investments from Reko Diq, Saudi Arabia, the Balochistan government, and the federal government.

During the meeting, Aurangzeb briefed Blome on Pakistan's efforts to implement "broad-based reforms in taxation, energy, and state-owned enterprises (SOEs)". The finance minister reiterated the government's commitment to raising the country's tax-to-GDP ratio to 13.5% by plugging loopholes and bringing untaxed sectors into the fold.

Despite these pledges, the government has struggled to tax traders effectively. While the IMF set a target to collect Rs10 billion from traders in the first quarter of the fiscal year, the government managed to collect only Rs1 million. Meanwhile, salaried individuals bore the brunt, paying Rs111 billion in taxes over the last three months□56% higher than the same period last year.

Aurangzeb also highlighted the government's transformation plan for the Federal Board of Revenue (FBR), which includes bringing in experts on the Board of PRAL, the FBR's IT arm, to improve tax collection efforts.

While the finance minister acknowledged that macroeconomic reforms were still a "work in progress," he pointed to pressing issues such as climate change and child stunting, which threaten to exacerbate inequality and disrupt economic growth in Pakistan over the long term, said the finance ministry.

Blome appreciated Pakistan's efforts to stabilise its macroeconomic environment and commended the government for undertaking challenging and bold reforms, particularly in the taxation and energy sectors, according to a statement from the finance ministry.

***Courtesy: Published in The Express Tribune, October 18th, 2024.***

**ROAD TO BAKU**

**By**

**Jamil Ahmad**

**IN 2015, the Paris Climate Accord, a legally binding international treaty, established a structured plan for climate action with step-by-step targets for emission reductions, aiming for net-zero greenhouse gas emissions by 2050. It acknowledged that reducing GHG emissions alone would not be enough to control climate change: mutually supportive adaptation policies would be necessary to protect vulnerable people from its impact. According to the Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report, some 3.6 billion people, almost half the global population, are highly vulnerable to climate change.**

The Paris Agreement, therefore, established a Global Goal on Adaptation to enhance adaptive capacity, strengthen resilience and reduce vulnerability to climate change in the context of its goal to limit the global temperature rise to 1.5 degrees Celsius above pre-industrial levels. This benchmark was based on the IPCC's analysis that crossing this threshold would unleash harsh environmental impacts, including severe heatwaves, frequent droughts and heavy rainfall — which are becoming common. Sadly, the Global Goal on Adaptation is yet to be operationalized.

For developing countries, the treaty also laid down a framework for financial, technical and capacity-building support, and "reaffirmed that developed countries should take the lead in providing financial assistance to countries that are less endowed and more vulnerable" for mitigation and adaptation. Developed countries had pledged, in 2009, to raise $100bn by 2020 for this purpose. Belatedly mobilized in 2022, this amount fell short of requirements, which are estimated at $600bn annually. Distressed by debt, most developing countries find it difficult to take climate action. They need sufficient financial means to raise adaptation to a level that guarantees a better degree of protection against the climate crisis.

In 2021, the Glasgow Climate Pact called for the doubling of "collective provision of climate finance for adaptation". But funding needs kept surging. Last year, UNEP estimated that the financial needs of developing countries for adaptation would soar from $215bn to $387bn by 2030. These figures are expected to be overtaken in this year's UNEP Adaptation Gap Report, due next month.

Climate COP29 in Baku, Azerbaijan, next month, has been dubbed the 'finance COP', and will seek to agree on a new global goal for climate finance to replace the unmet $100bn adaptation target. The new goal is expected to be broad-based and open to contributions from the private sector and others.

Precariously perched, developing countries are expecting concessional finance to be prioritized by COP29, as more loans will only add to their debt burden. Discussions in Baku will be informed by the report of the Independent Expert Group on Climate Finance, tasked by COP to assess how the climate finance system can support the implementation of the Paris Accord. The report notes that insufficient investment in

developing countries in key areas — a just energy transition, adaptation and resilience, conservation and restoration of nature, etc — was the primary reason that the Paris Agreement went off track. The report concluded that developing countries and emerging economies, minus China, would need around $2.4 trillion annually by 2030 to invest in climate change and nature.

The expert group recommended that immediate debt constraints and lack of fiscal space impeding the ability of poor and vulnerable countries to invest must be tackled urgently. It said that country leadership was crucial for committed engagement with the private sector, MDBs, donors, and private philanthropy to unlock investment at scale. An integrated approach is required to mobilize all sources of finance — public and private, domestic and international. Domestic resource mobilization is needed to anchor the macroeconomic sustainability of all finance, while the elimination of harmful subsidies and imposition of carbon taxation are crucial to revenue generation.

Insufficient concessional climate finance for developing nations would render international efforts ineffective, aggravate the climate crisis, and deepen mistrust between the developed and developing countries. The expert group has urged developed countries to triple bilateral concessional finance by 2030.

Nearly a decade after its adoption, the Paris Agreement remains instrumental in spurring climate action and promoting low-carbon solutions across economic sectors. Overall, however, the agreement risks missing its goal of keeping the temperature rise under 1.5°C, unless fresh vigour, stronger political commitment and adequate financial resources are urgently pumped into its pipelines.

***Courtesy: Published in Dawn, October 20th, 2024***

## SIFC FOR PRIORITISING LOCAL OIL PRODUCTS

**By**

**Zafar Bhutta**

Directs Petroleum Division to address issues hampering refinery upgrade plans

**ISLAMABAD: The Special Investment Facilitation Council (SIFC) has directed the Petroleum Division to address the key challenges that hamper work on multibillion-dollar plant upgrading projects of oil refineries.**

In that regard, the first issue was the grant of oil import permission to a certain company despite available stocks in the country, which landed in the SIFC. It directed the Oil and Gas Regulatory Authority (Ogra) chairman to ensure that first priority was given to lifting products from local refineries.

Earlier, Ogra allowed an oil company the import of petroleum products, prompting a sharp reaction from refineries. Even, the Oil Companies Advisory Council (OCAC), which represents refineries and oil marketing companies (OMCs), took up the matter with Ogra and the federal government, arguing that a company was importing diesel, though the country had over 40 days of stocks – the highest in history.

Sources revealed that the SIFC held a meeting on refineries' request on Tuesday, chaired by Special Assistant to the PM and SIFC Apex Committee Chairman Dr Jehanzeb Khan, who had earlier been deputy chairman of the Planning Commission.

The meeting was also attended by Ogra chairman, additional secretary of the Petroleum Division and chief tax policy of the Federal Board of Revenue. Refineries were led by Adil Khattak, OCAC Chairman and CEO of Attock Refinery Limited. All other refineries were also represented by their chief executive officers.

During the meeting, four key decisions were taken on issues highlighted by the oil refineries. The SIFC directed the Petroleum Division to resolve the sales tax matter positively by November 12, 2024.

The government had announced some measures in the federal budget for fiscal year 2024-25 regarding exemption from sales tax on petroleum products.

All refineries drew attention of the government to a significant amendment to the Sales Tax Act 1990, proposed through the Finance Bill 2024, to exempt motor spirit (petrol), high-speed diesel, kerosene oil and light diesel oil from sales tax.

These products were previously zero-rated but the new measure effectively restrained refineries from claiming approximately 70% of the input sales tax paid on taxable purchases and services.

Refineries were of the view that the measure would impact their investment plans for upgrading oil processing plants.

Oil smuggling

The other challenge facing the oil industry was increasing oil smuggling from Iran. The wide availability of smuggled products, particularly in border and adjoining areas, poses a serious threat to sales of local refineries and OMCs.

The oil industry has repeatedly taken up the problem of unchecked smuggling with Ogra and the federal government, demanding steps to curb the flood of illegal supplies.

The SIFC directed the Petroleum Division, Ogra and provincial governments to take effective measures, with support from the industry, against the smuggling of petroleum products and to ensure better product quality.

It urged Ogra chairman to ensure and certify that first priority was given to the purchase of local refineries' products and in case of import of deficit products, priority was accorded to Pakistan State Oil (PSO), followed by other OMCs.

The SIFC emphasised that import of only deficit products should be allowed in consultation with the oil industry.

Keeping in view the deadline of October 22, 2024 for signing plant upgrade agreements, the SIFC chairman asked the Petroleum Division to prepare a summary for extension in the time frame, noting that delay in implementation of the Brownfield Refinery Policy had already caused a loss of billions of dollars to the national exchequer.

Earlier, the Cabinet Committee on Energy extended the deadline for inking agreements between Ogra and refineries for six months as two refineries – Pak Arab Refinery Limited (Parco) and Byco – sought more time. According to sources, these refineries are now ready to sign deals.

Parco has planned a long-term investment of over $1 billion for setting up a hydrocracker unit to convert furnace oil into petrol and diesel, which will ensure energy security in the country.

Parco requires a capital injection of $500 million for upgrading its plant, but investors want to make long-term investment rather than providing funds for producing only Euro-5 petroleum products.

All refineries had objections over three issues including sales tax exemption, oil smuggling and import permission despite available stocks in the country.

Sources said that refineries also wrote a letter to the SIFC for removing hurdles standing in the way of pressing ahead with plant upgrade plans.

***Courtesy: Published in The Express Tribune, October 24th, 2024.***

# UTILIZING ORANGE PEEL WASTE FOR SUSTAINABLE BIOPLASTIC PRODUCTION: A SOLUTION FOR ECO-FRIENDLY PACKAGING

**By**

Rimsha Tanveer[1], Abdullah Yasar, Iqra Wasif, Laiba Haider Naqvi, Fizza Ayub, Amtul Bari Tabinda

## Abstract

This study explores the extraction, production, and optimization of orange peel-based bioplastics, focusing on their environmental and economic impact. Various extraction methods, including acid hydrolysis, enzymatic hydrolysis, and solvent extraction, are examined, emphasizing the importance of process optimization for improved bioplastic properties. The role of plasticizer selection in determining mechanical, thermal, and barrier properties is analyzed, alongside processing techniques such as solvent casting, extrusion, and compression molding. The physicochemical, mechanical, and biodegradable properties of these bioplastics are evaluated to assess their suitability for packaging, agricultural, and medical applications. A market analysis reveals significant potential for orange peel-derived bioplastics in various industries, while challenges like production costs and feedstock availability persist. Biodegradation mechanisms, factors affecting degradation rates, and health and safety considerations are explored. The study also highlights the socio-economic benefits, including waste management, job creation, and cost-effectiveness, underlining the promising role of orange peel-based bioplastics as sustainable alternatives to conventional plastics.

**Keywords:** Oranges, Bioplastic, Plasticizer, Sustainability, Recyclable

## 1. Introduction

The cheap, durable, and versatile nature of plastics has caused a rise in their demand worldwide over the last few decades. Nevertheless, this increase has resulted in quite a few negative outcomes in the shape of pollution, waste accumulation, and fossil resources' exhaustion (Geyer et al., 2020). Consequentially, a substitute for these petroleum-based plastics is needed to mitigate the above-mentioned issues. Produced from replenishable resources, bioplastics have arisen as an encouraging proposition. The use of orange peel, the inexhaustible resource in question, has attained notable attention for bioplastic production. This research speculates the aptitude of orange peel-based plastics as a substantial packaging material.

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**Figure-1**: Bioplastic generation creates a closed loop cycle that creates 0 waste.

Millions of tons of orange peels are produced globally, as a waste product from the citrus industries (Ojha et al., 2020). The under usage and disposal of orange peel has led to pollution and a rise in greenhouse gases' emission. Using the otherwise waste product for bioplastics will help industrialize the underutilized resource and at the same time decrease the pollution (De Carvalho et al., 2023). To convert orange peels to bioplastics, cellulose, pectin, hemicellulose and other important components are to be extracted which are processed further into eco-friendly packaging (García et al., 2020)

The practicability of deriving bioplastics from orange peel has been demonstrated by several other researches. For example, bioplastics from orange peels were successfully produced by (Robles et al., 2023); attaining likeable thermal and mechanical properties, using glycerol as a plasticizer, for packaging applications. Regardless, for further improvement of the overall performance, there is a requirement to perfect the production process. The main goal of the research is to enhance the bioplastic production process from orange peels by examining factors that affect the quality of the product. These consist of processing techniques, plasticizer types and extraction methods. Added to this, the chief objective of this research is to assess the biodegradable, mechanical and physicochemical properties of bioplastics to gauge their substantiality for packaging applications.

## 2. Synthesis of Bioplastic

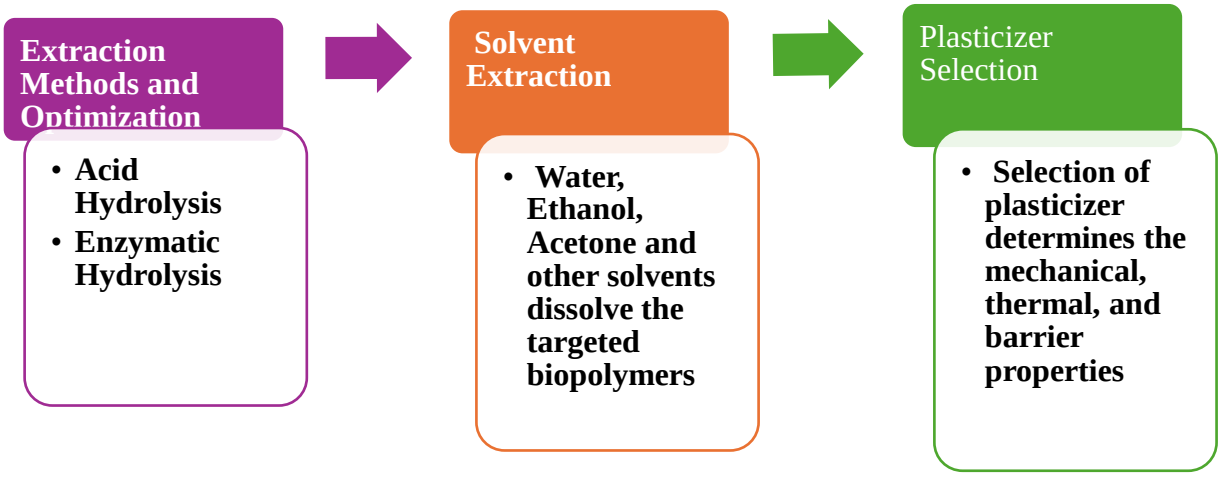



**Figure-2:** Processes involved in the synthesis of bioplastic.

### 2.1. Extraction Methods and Optimization

Withdrawing the biopolymers from the orange peels is a crucial stage in the manufacture of bioplastics, as it decides the excellency and quantity of the eventual product. Different methods for extraction such as acid hydrolysis, enzymatic hydrolysis, and solvent extraction have been found in previous studies (da Rosa Zavareze er al., 2011).

#### 2.1.1 Acid Hydrolysis

This method has become one of the more frequently utilized processes for extracting biopolymers from plant-based materials like orange peels due to its ease and cost efficiency (Campos-Requena et al., 2109). Acid hydrolysis refers to the process of hydrolyzing complex polysaccharides into simpler monosaccharides using strong acids at high pressures and temperatures (Allen et al., 2021). Elements such as concentration of acid, temperature and reaction time play an integral part in optimizing acid hydrolysis processes. They ensure maximum purity, yield from extracted material, and help facilitate its extraction process (Rokka et al., 2020) have reported that sulfuric acid concentration of 1.5% at 121 degrees Celsius with an incubation time of 120 minutes produced the maximum yield in their experiments.

#### 2.1.2 Enzymatic Hydrolysis

Enzymatic hydrolysis to extract biopolymers from waste is more eco-friendly than acid hydrolysis (Siracusa et al., 2022). Pectinases and cellulases break down polysaccharides inside cell walls into monosaccharides via pectinases/cellulases; enzyme concentration temperature pH incubation time are the keys to optimizing this process concentration, temperature pH incubation time in combination with enzyme concentration/cellulases/cellulases/cellulases at 50°C/pH4.5 for 24 hours resulted in higher yielding reduction sugars yield Araujo et al. (2020) found high yielding results using 0.5% cellulases/pectinases at 50°C/pH4.5 for 24 hours resulted in increased reduction sugars.

### 2.2 Solvent Extraction

This is another method used to extract biopolymers, for pectin, one of the main components of these peels. In this method, water, ethanol, or acetone and other such

solvents are used to dissolve the targeted biopolymers, which are later separated from the solid residue by filtration and centrifugation (Rivas et al., 2023). Elements like solvent type, solvent-to-solid ratio, temperature, and extraction time to maximize the yield and purity of the extracted biopolymers determine the optimization of solvent extraction (Melchor-Martínez et al., 2022). For instance, it was found by Araujo et al. (2020) that high yields of pectin can be harvested from orange peels using a water-to-solid ratio of 20:1 at 85°C for 60 minutes.

Various extraction methods have been pondered upon for extracting biopolymers from orange peels, each with their own pros and cons. The optimization of these extraction methods is critical for upgrading the properties and performance of the products. Through comprehending the influence of elements such as acid or enzyme concentration, temperature, and reaction time, researchers can modify the withdrawal to attain the likeable properties of the biopolymers.

### 2.3 Plasticizer Selection and Influence on Bioplastic Properties

The selection of plasticizers is a crucial part of producing bioplastics with likeable properties. The reduction of intermolecular forces that lie between polymer chains are shown to increase plasticity, the ability to be processed, and extensibility, as a function of the plasticizers (Yaradoddi et al., 2022). The selection of plasticizer determines the mechanical, thermal, and barrier properties of the resulting and can thus determine their viability for various applications. Several plasticizers have been assessed to be used production of bioplastics, like synthetic plasticizers and glycerol, sorbitol, and citric acid (Araújo et al., 2020). Each choice of plasticizer has its own effects on bioplastics.




**Figure-3**: Different types of plasticizers that can be utilized for making bioplastic.

Glycerol is a natural plasticizer. It has shown to upgrade the ability to be processed and the malleability of the bioplastics but reduction of tensile strength and increase in absorption of water are some drawbacks (Xie et al., 2023). Mechanical and thermal properties of bioplastics can be enhanced by sorbitol, another natural plasticizer. But

it may adversely affect their barrier properties (Mathew, 2023). Enhanced mechanical properties and water resistance can be achieved using synthetic plasticizers, such as PEG and DBP. But it will be a compromise on being eco-friendly (Gomez et al., 2019). As the research advances, unique plasticizers are being explored to invent bioplastics with desired properties. For example, studies have shown investigations regarding the influence of mixing different plasticizers or blending various additives, such as nanocellulose or natural fibers, to enhance the mechanical, thermal, and barrier properties of the bioplastics (Averous et al., 2021).

The performance and properties of the products depend on the type of plasticizer selected. After the researchers have an apprehension of how bioplastic quality is affected using different plasticizers and mixtures of them, they would be able to produce plastic with desired characteristics which would be useful for a range of applications. Future research about this topic shall assist in optimizing the selection of plasticizers and later participate in the production of environmentally friendly non-toxic substitutes to conventional petroleum-based plastics.

### 2.4 Processing Techniques for Orange Peel-Based Bioplastics

The techniques that are adopted for processing bioplastics also significantly influence their performance and quality. Different methodologies have been assessed, such as solvent casting, extrusion, and compression molding. Each of these give rise to a novel property in the product (Gupta et al., 2020).

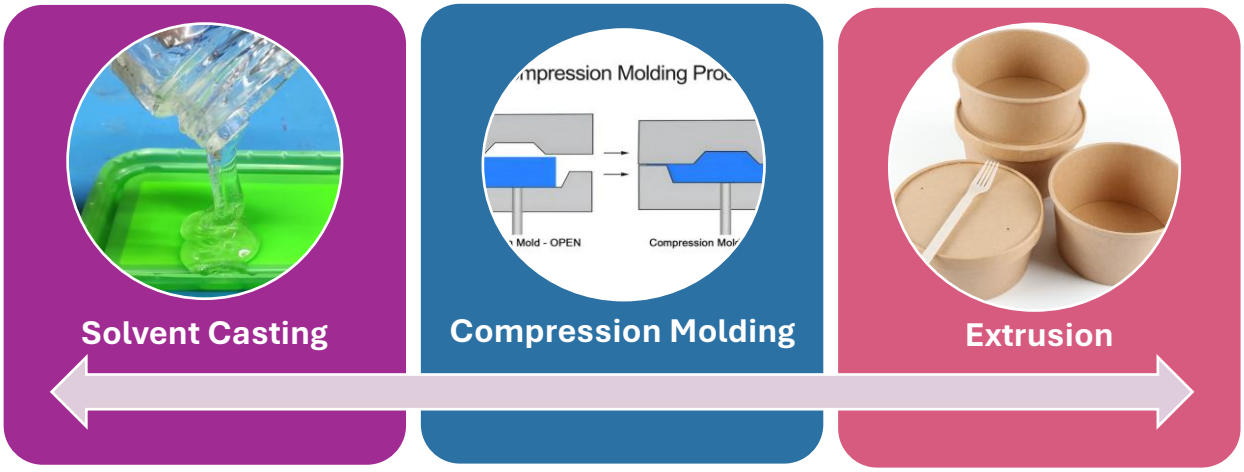



**Figure-4**: Processing Techniques for Orange Peel-Based Bioplastics

Solvent casting is dissolving the biopolymer and plasticizer in a solvent, followed by the evaporation of the solvent to form a solid film (Dibha et al., 2023). It is also a known method to produce films with exceptional optical and barrier properties. But this can be restricted due to selection of the solvent and the control of the evaporation with precision (Xie et al., 2023). The other method for production of bioplastics is compression molding. Here the biopolymer and plasticizer are merged, and a homogeneous melt is resulted from heating, which is later compressed into whatever shape desired (Lee et al., 2023). Compression molding is especially useful for thicker film production and for molded parts. The drawback being the uneven distribution of plasticizer and the biopolymer being potentially degraded due to elevated temperatures.

Lastly, extrusion. It involves the melting and mixing of the biopolymer and plasticizer, from which film, filaments or other shapes can be formed when the mixture is forced

through a die (Hanafi & Sapawe, 2020). Extrusion produces materials with consistent characteristics and those are very suitable for large-scale production. Nevertheless, this process can result in biopolymer degradation and would require the parameters of the process to be optimized significantly for attaining the properties desired. The properties and performance crucially depend on the choice of processing techniques. Through apprehending the influence of different methods and optimization of their parameters, the researchers could produce bioplastics with desired properties which may be suitable for diversified applications. Increasing research in this section shall participate in the production of better substitutes to the conventional petroleum-based plastics.

## 3. Properties of Bioplastic

It is significant for determining the potential applications and their limitations to assess the physicochemical, mechanical, and biodegradable properties of bioplastics. Each of these properties is affected by elements such as the extraction method, plasticizer selection, and processing techniques.

### 3.1. Physicochemical properties

The chemical composition, molecular weight, and thermal stability participate in determining the ability to be processed and performance of the bioplastics (Sánchez-Orozco et al., 2024). As an example, for the processes of extrusion and molding, bioplastics should be thermally stable. As well as for their performance in elevated temperatures (Araújo et al., 2019). The choice of plasticizer, extraction method, and the presence of additives have shown to influence these properties.

### 3.2. Mechanical properties

The tensile strength, elongation at break, and Young's modulus, are critical for gauging their suitability, particularly in the packaging industry. It is expected from the orange peel-derived bioplastics to attain mechanical properties as compared to the traditional plastics, albeit it is required to be optimized further. These properties can be affected by elements like plasticizer selection, processing conditions, and the incorporation of additives (Sánchez-Orozco et al., 2024).

### 3.3. Biodegradable properties

This particular one is an advantage, as it assists in the reduction of adverse influence on the environment which is linked with conventional plastics. This feature can be investigated by noticing the weight loss, changes in mechanical properties, or the release of carbon dioxide during composting under controlled conditions (Faruk et al., 2021). Elements like plasticizer selection, the presence of additives, and the processing conditions can affect the rate of biodegradation. (Araújo et al., 2019).

### 3.4. Endurability and Ecological Impact

The endurability and the ecological impact of orange peel-based bioplastics are important aspects that should be taken into consideration when their potential is being assessed to be used as substitutes to conventional petroleum-based plastics (Lee et al., 2023). The environment can be influenced in many ways by the production, use, and disposal of bioplastics, and this influence is dependent upon elements like end-of-life management, processing methodologies and feedstock sourcing.

### 3.5. Feedstock sourcing

The use of orange peel as feedstock for production of bioplastics has come up as a method to put the agro-industrial wastes to good use, such waste would otherwise participate in generating more pollution and waste management challenges (Ojha et al., 2020). Conversion of waste into products that have value, orange peel-based bioplastics can participate in closed-loop economy and alleviate the influence of waste disposal from upon the environment.

### 3.6. End-of-life management

Compares favorably to conventional plastics which continue to harm the environment and lead to pollution, the biodegradability of orange peel-based bioplastics presents an attractive option. Yet, the true environmental footprint of waste disposal depends upon a series of conditions in which bioplastics degrade; such as temperature, humidity and presence of microorganisms (Araújo et al., 2019). For optimal decomposition of bioplastics to avoid further pollution it is vital that effective waste management strategies and infrastructure are in place.

## 4. Potential Applications and Market Analysis

A wide range of potential applications and market opportunities are presented by orange peel-derived bioplastics, which are due to their novel properties, such as biodegradability, renewability, and consistency for several production processes. In this area, the potential applications of these bioplastics will be discussed, and a market analysis will be provided, with the focal point based on the key drivers, challenges, and opportunities within this growing industry.

### 4.1. Potential Applications

Packaging industry holds the most potential in applications of orange peel-based bioplastics, particularly for food packaging (Lee et al., 2023). Bioplastics can be used to produce producing films, trays, containers, and other packaging materials that require good barrier properties, malleability, and biodegradability. Through substitution of petroleum-based plastics with bioplastics, the ecological footprint linked with the waste produced through packaging can be decreased.

**Table-1:** Comparison of Orange Peel Bio Plastic with Other Bio Plastics

| **Component** | **Orange Peels based Bio plastic** | **PLA Bio plastic** | **PHA Bio plastic** |
|---|---|---|---|
| **Main Source** | Orange Peels | Starch, Corn | Microorganisms |
| **Impact on Environment** | Less | Less | Less |
| **Biodegradation Time** | Fast | Moderate | Moderate |
| **Decomposition Tenure** | Months to 1 year | Years | Years |
| **Toxicity** | Non Toxic | Non Toxic | Non Toxic |
| **Applications** | Packaging | Disposable Items | Medical Implants |
| **GHG Release** | Very Low | Very Low | Very Low |

The parallel assessments between orange peel-based and other waste-based bioplastics spotlights the requirement for continued research and the optimization of

their characteristics to enhance the potential of their applications and ecological advantages.

### 4.2. Agricultural Applications

Applications for orange peel-based bioplastics can also be found in the agricultural sector, for instance, the production of mulch films, seedling pots, and biodegradable twine (Fernández-Cornelio et al., 2019). Plastic waste in agricultural settings can be decreased with assistance from these products. Consistent farming practices with reduced ecological impact of agriculture can also be promoted.

### 4.3. Medical Applications

Several medication applications involve bioplastics, such as drug delivery systems, sutures, and implantable devices (Pietrzak et al., 2022). An environmentally friendly substitute for traditional plastics can be provided by orange peel-based bioplastics, with their potential ability to be customized and their biocompatibility.

### 4.4. Market Analysis

The global bioplastics market is promised to witness significant development, due to elements such as increasing environmental concerns, stringent regulations on plastic waste management, and the increasing demand for substantial materials (Grand View Research., 2021). Regardless, there are various hurdles that the industry must overcome, which include high production costs, restricted availability of feedstock, and the requirement for future research and growth to upgrade the bioplastic characteristics.

Great significance is held by the promise of orange peel-based plastics in various applications, especially in the packaging, agricultural, and medical arenas. The markets linked to these sectors have been foreseen to dramatically grow due to elements such as environmental concerns, regulatory pressures, and consumer demand for substantial products. Nevertheless, continued research, development and investment are critical to fully accomplish this potential.

To optimize the characteristics and to ensure the endurability of these products, it is essential to apprehend the elements that influence their rate of biodegradation. Ongoing studies are required to demonstrate the administrations of biodegradations and to recognize maneuverings for customizing the rate of degradation of these materials to satisfy different applications and ecological situations.

## Conclusion

Waste reduction and management are significant social and ecological issues which are communicated by the utilization of orange peel-based bioplastics. The valorization agro-industrial waste materials for bioplastic production can participate in regenerative economy where the waste is assigned merit for value-added applications. This method not only alleviates the ecological footprint but also decreases the landfills. Employment vacancies are another important socio-economic aftermath of the industry. The manufacturing and processing can give rise to new job opportunities in agriculture, waste management, and the manufacturing sector (Shen et al., 2020). The rise in substantial packaging demand has promised significant growth for the industry, by participating in creating more employment opportunities and economic development. Money-making is a critical economic element, which affects the adoption of bioplastics. Although they have various ecological positives in comparison to the traditional plastics, the higher manufacturing costs may induce hurdles in widespread adoption.

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# CHALLENGES OF CLIMATE CHANGE IN GILGIT BALTISTAN WITH SPECIAL FOCUS ON AGRICULTURE AND ROAD INFRASTRUCTURE

**By**

**Tania Haider[1], Syeda Fizza E Batool[1], Abdul Qadir[1]**

## Abstract

The northern area of Pakistan, particularly Gilgit Baltistan, has been the most vulnerable to climate change in recent years, as evidenced by the changing shift in temperature and precipitation trends in the region. Research studies have shown that GB has exhibited twice the warming trend compared to the lower elevations of Pakistan in the past 50 years. Major events like floods, melting of glaciers, warmer winters, and landslides have been occurring as a result of climate change, and have harmed the vulnerable ecosystem of the region. From 1984 to 2013 the area's temperature and precipitation have shown fluctuations according to the data gathered. It is observed that rainfall now occurs between February and May. All these changes have drastically impacted the infrastructure and agriculture of the region. Owing to the geographic location of Gilgit Baltistan, the region is of strategic and economic significance and hence the road development, for trade and investment, is very important. Similarly, the local farmers have also been forced to adopt various adaptation strategies, in order to mitigate the adverse impacts of climate change on agriculture. Furthermore, phenomena such as Glacial Flood Outburst Lakes, landslides, and flashfloods have also become increasingly common during the last few decades.

This review investigates various impacts of climate change on road infrastructure and agriculture in the region of Gilgit Baltistan. It focuses on the diverse impacts of changing climatic conditions on major crops of the region, explaining varying yields due to changing weather patterns. Moreover, it also provides insight into the impact of climate change on roads and transportation, emphasizing the vulnerability of infrastructure. The article has presented information in the form of some prominent drastic events that occurred in the region over last few years due to changes in climate, and have specifically wreaked havoc on roads and agricultural production. The comprehensive review emphasizes that adaptation strategies like resilient and durable infrastructure, and up-to-date land management systems need to be introduced in the region by mobilizing and creating awareness among the local community, in order to tackle the alarming situation caused by climate change.

**Keywords:** Climate change, Gilgit Baltistan, GLOFs, Roads, Agriculture, Resilience

## Introduction

The Northern area of Pakistan comprises of mountains, divided into Karakoram, Himalayas, and Hindukush ranges. With its administrative center at the town of Gilgit, the Northern Areas covers an area of 72,971 km² (28,174 mi²) and has an estimated population. The Northern Areas is administratively divided into two divisions which, in turn, are divided into seven districts the two Baltistan districts of Skardu and Ghanche, and the five Gilgit districts of Gilgit, Ghizer, Diamer, Astore, and Hunza-Nagar. The main political centers are the towns of Gilgit and Skardu.

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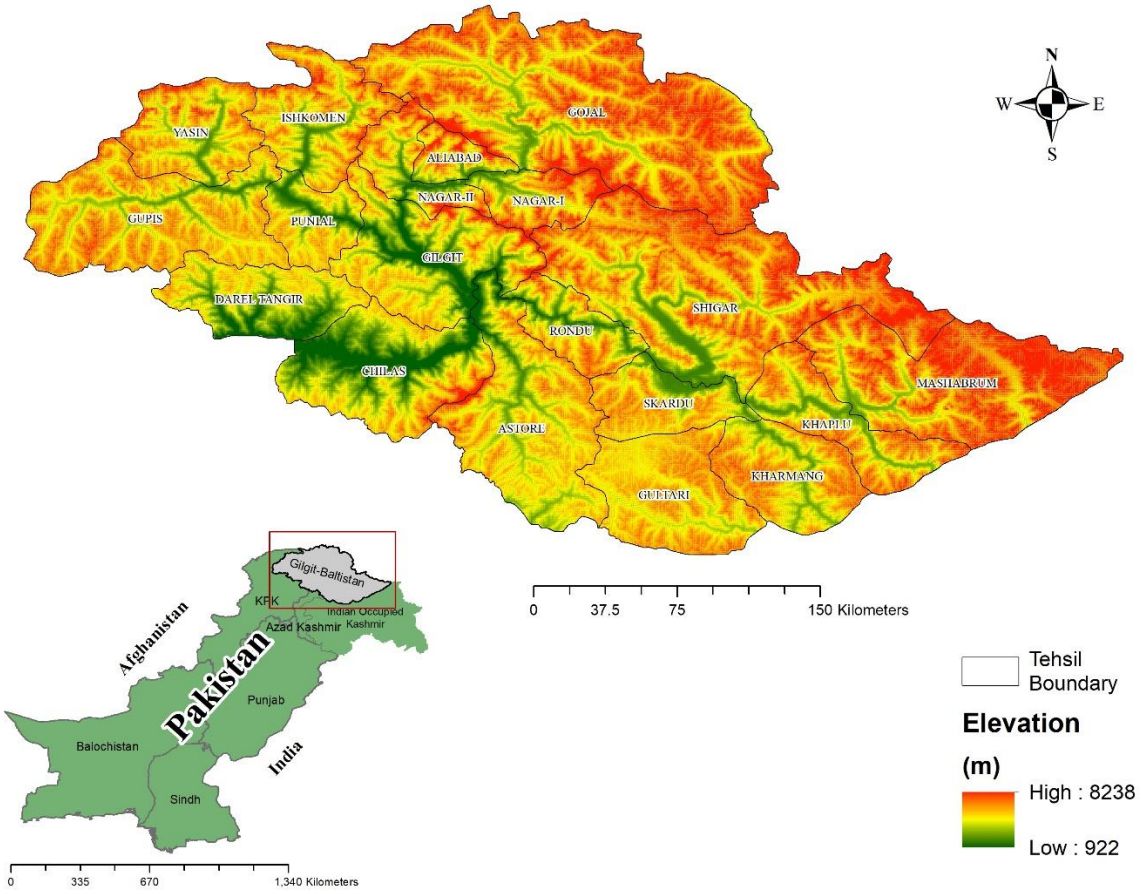



Figure-1: Map of Gilgit and Baltistan, showing variations in altitude and topography

The Northern area of Pakistan comprises of mountains, divided into Karakoram, Himalayas, and Hindukush ranges. With its administrative center at the town of Gilgit, the Northern Areas covers an area of 72,971 km² (28,174 mi²) and has an estimated population. The Northern Areas is administratively divided into two divisions which, in turn, are divided into seven districts the two Baltistan districts of Skardu and Ghanche, and the five Gilgit districts of Gilgit, Ghizer, Diamer, Astore, and Hunza-Nagar. The main political centers are the towns of Gilgit and Skardu (Figure 1.) The climate of northern areas of Pakistan is greatly diverse and influenced by global circulation patterns and local topography. The area is prone to severe floods that are caused by glacier lake outbursts and dam-breaks due to landslides. The climate here is characterized by variable temperatures and precipitation, where snow and glacier melt are significant contributors to the hydrological system. Changes in temperature and precipitation have been observed over the course of the 20th century, which could have an impact on flood generation. Additionally, the region's vulnerability to landslides and debris flows further contributes to its flood risk..(Awan, 2002)

Pakistan is responsible for less than 1% of the world's carbon emissions, yet it is one of the countries most severely impacted by climate change. According to the Global Climate Risk Index, Pakistan is currently the fifth most vulnerable country to climate change. From 1999 to 2018, the country has lost almost ten thousand lives and suffered economic losses worth 3.8 billion USD due to the effects of climate change.

Pakistan has experienced changing seasonal weather patterns, rising temperatures, variability of monsoons, and melting of glaciers in the north, which have all been exacerbated by recurrent extreme weather events and natural disasters. These issues are some of the effects of climate change that Pakistan has had to confront in recent years.

Pakistan has been vulnerable to foods, droughts, glacial lake outbursts, cyclones, and heatwaves as a result of climate change. In terms of the affect in Northern areas of Pakistan, it is expected that there will be a permanent deformation with reduction in the days of winters and an increase in the summer days.(*Climate Crisis in Pakistan*, 2023)

This article discusses the effects of climate change on road infrastructure and agricultural production in Northern Pakistan. By drawing evidences from different national and international researches, the article adds to the ongoing conversation about the impact of climate change on these two aspects, highlighting the vulnerability of the northern region of the country.

### *Change in Temperature*

Climate change is a crucial matter for developing countries like Pakistan. Within the next few years, there will be an increase in the annual mean temperature from 3$^{o}$ C to 5$^{o}$ C. This would mean there will be changes in annual rainfall, river flow and sea level, negatively affecting various areas of Pakistan.

## Impacts of Climate Change on Agriculture

### *Major crops of the Northern Regions of Pakistan*

The Northern Irrigated Plains of Pakistan, which include areas like Peshawar and Nowshera, are known for cultivating Wheat, Maize, and Sugarcane. According to the farming area distribution, Wheat covers the largest portion at 40.1%, followed by Maize at 29.7%, and Sugarcane at 22.4%. However, when it comes to production, Maize takes the lead at 46.6%, followed by Wheat at 29.1%, and Sugarcane at 17.7%. The farming landscape in regions like Abbottabad and Mansehra within the same Northern Irrigated Plains is different, with Wheat covering 29.1%, Maize 56.9%, and Sugarcane 11.5% of the area. But in terms of production, Maize dominates at 76.7%, followed by Wheat at 8.5%, and Sugarcane at 13.7%. When we move to the Wet Mountains, represented by Abbottabad and Mansehra, Wheat occupies 56.9% of the area, and Maize 40.1%. However, Wheat contributes 51.7% to the production, and Maize closely follows with 46.9%. Shifting to the Northern Dry Mountains, which include areas like Chitral and Swat, we see a different farming landscape where Wheat dominates the area with 65.1%, followed by Maize at 29.2%, and Rice at 5.5%. But in terms of production, Wheat remains the primary contributor at 62.8%, followed by Maize at 28.5%, and Rice at 8.6%. It's worth noting that the difference between the percentages for area and production highlights the complexity of agricultural patterns in these regions (Table-1).

Table 1. Crops of Northern Areas of Pakistan and their Share in crop production (Hussain & Bangash, 2017)

| *Zone* | *Crops Included* | *Selected Regions* | *% Share of Crops with Respect to Area* | *% Share of Crops with Respect to Production* |
|---|---|---|---|---|
| *Northern Irrigated Plains (b)* | *Wheat, Maize, Sugarcane* | *Peshawar, Nowshera* | *Wheat 40.7*<br>*Maize 29.1*<br>*Sugarcane 22.4* | *Sugarcane 81.5*<br>*Wheat 8.7*<br>*Maize 7.7* |
| *Wet Mountains (Zone VI)* | *Wheat, Maize* | *Abbottabad, Mansehra* | *Maize 56.9*<br>*Wheat 41.6* | *Wheat 46.7*<br>*Maize 51.7* |
| *Northern Dry Mountains (Zone VII)* | *Wheat, Maize, Rice* | *Chitral, Swat* | *Wheat 65.1*<br>*Maize 29.2*<br>*Rice 5.5* | *Wheat 62.8*<br>*Maize 28.5*<br>*Rice 8.6* |

### *Temperature and Water Requirements for Various Crops*

The cultivation of major crops like Wheat, Rice, Cotton, and Maize is influenced by their temperature and water requirements, which exhibit unique characteristics (Table 2).. For instance, Wheat grows best in temperatures ranging from 3-4°C to 30-34°C and requires a moderate water supply of 450-650 mm. Rice, on the other hand, prefers flooded conditions and needs a substantial water supply ranging from 1000-2000 mm, with a broader temperature range of 10-12°C to 36-38°C. Cotton can withstand high temperatures of up to 43-45°C and requires a water supply of 600-750 mm. Maize is adaptable to temperatures ranging from 10°C to 33°C and has a moderate water requirement of 550 mm. It's worth noting that rice has the highest water demand, while cotton has exceptional heat tolerance, highlighting the distinct environmental preferences of these staple crops. (Khan, 2004).

Table 2. Temperature Thresholds and Average Crop Water Requirements (Khan, 2004)

| Crop | Temperature Water Requirements | | |
|---|---|---|---|
| Wheat | Temperature | Minimum | 3-4 °C |
| | | Optimum | 25°C |
| | | Maximum | 30-34°C |
| | Water Requirement | | 480mm |
| Rice | Temperature | Minimum | 10-12°C |
| | | Optimum | 30-32°C |
| | | Maximum | 36-38°C |
| | Water Requirement | | 1500mm |
| Cotton | Temperature | Minimum | 20°C |
| | | Optimum | 27-35°C |
| | | Maximum | 42-45°C |
| | Water Requirement | | 620mm |
| Maize | Temperature | Minimum | 16.7-23.3°C |
| | | Optimum | 20-22.7°C |
| | | Maximum | 22-32°C |
| | Water Requirement | | 550mm |

### *Impacts of Climate Change on Agriculture*

Climate change projections suggest divergent impacts on crop production especially of wheat in various parts of northern region. In areas of high mountain ranges like Chitral, farmers are expected to experience increased wheat yields, leading to higher income and a potential decrease in poverty levels. Conversely, in areas of mid or sub mountain ranges like Peshawar, farmers face adverse consequences, with climate change projected to reduce wheat yields, diminishing farmers' earnings and potentially pushing more individuals below the poverty line.

A study was conducted in 2012 by the Institute of Agricultural Extension and Rural Development at the University of Agriculture in Faisalabad, Pakistan. The study found that climate change was having a negative and irreversible impact on agriculture in northern areas, particularly due to the limited resources and space available for terrace farming. Farmers reported high temperatures, unpredictable rainfall and temperature patterns, high precipitation rates, floods, and attacks from pests and diseases as significant impacts. (Safdar et al., 2014)

### *Impacts of Temperature and Altered Rainfall Patterns*

In the high-altitude mountain ranges such as Karakorum, Hindu Kush, and Himalayas the increasing temperatures, particularly during winters, are shortening the growing season of crops. This phenomenon has both negative and positive impacts on wheat crops in different regions. For example, it has a positive effect on wheat yield in areas at higher elevations like Chitral Valley in the Hindu Kush range, a 1$^{o}$C rise in mean temperature during vegetative growth enhances wheat productivity to the tune of 6.4 percent (Ahmad et al., n.d.), but harms wheat yield in sub-mountain regions like Sawat and Kaghan. However, in the case of high mountain areas, this temperature increase may lead to the possibility of growing two or more crops, including wheat and barley, per year, and the crop area of these crops might also expand accordingly. (S. S. Hussain et al., 2005)

Furthermore, a research conducted in 2017 analyzed the effect of climate change on major crops in four agro-climatic zones in Pakistan, with a focus on the northern areas and mountains. The study found that temperature fluctuations (maximum, minimum, and average temperatures) have a significant impact on crop yields, and an increase in temperature generally has a positive effect on major crops except for maize. However, deviations from optimum temperature levels, either too high or too low, prove detrimental to crop yield. Rainfall, on the other hand, has a positive impact on most crops in selected zones, except for maize in Wet Mountains of Abbottabad and Mansehra, and Northern Dry Mountains of Chiral.(A. Hussain & Bangash, 2017)

Rising temperatures have resulted in a shortened reproductive phase for crops, lower yields, and difficulties in raising young animals. Due to a lack of awareness, many locals continue to cut down trees for cooking and heating purposes without planting new ones, contributing to overall temperature increases that can cause glacial melt and flash floods. Additionally, longer winters, due to shift in the overall climatic patterns, have also spread diseases among crops, caused shortages of feed and fodder for livestock, and delayed sowing and harvesting periods, leading to a decrease in overall crop yield. (Safdar et al., 2014)

### *Adaptation Strategies of Locals*

During the interviews with local farmers, it was discovered that in order to adapt to climate change, the majority of them have begun planting multiple crops, such as corn,

wheat, and maize, in the same fields.(Safdar et al., 2014) Farmers across the country have become aware of the negative effects of climate change on agriculture. As a result, they have started to delay the sowing of wheat by 2-3 weeks, from mid-October to early November, in order to avoid the detrimental impacts of higher-than-normal temperature levels. (Ahmad et al., n.d.) Only a small number of farmers have switched to livestock due to the low yield of crops, and a very small proportion of locals have reduced the cutting of trees.(Safdar et al., 2014)

**Impact of Climate Change on Roads**

A huge impact of climate change is upon the infrastructure in any economy. In Pakistan's northern area, transportation place an important role in people's lives. However, effects of climate change are prominent within this sector. The conditions to travel become stressful due to the non-resilience of the roads and pavements to climate change. The old infrastructure is vulnerable to these extreme changes in the environment throughout the year. This can be in the form of heavy rainfall, eventually leading to flooding. Similarly, recurrent landslides also damage the road structure and usability. It eventually leads to economic cost of interruptions in the operation of the transportation systems, which prevent employees from going to work; shoppers from getting to stores; and goods from being delivered to factories, warehouses, and stores.(Asian Development Bank, 2017)

The roads are built upon the data of expected environmental changes it will face throughout its lifetime. However, with unpredicted changes in the climate today, there is a huge implication on the performance and lifetime of these roads.

***Effect of temperature***

In Pakistan, climate change is leading to increased temperatures throughout the country. It is evident through research that higher elevation areas have shown double warming trends as compared to the areas of lower altitude. For instance, the temperature rise in Gilgit Baltistan during the last 40 years was recorded to be 1.5 °C as compared to the 0.76 °C for the overall region of Pakistan. It is a matter of concern as the northern area is home to thousands of glaciers which are sensitive to increasing temperatures (Tariq et al., 2014). Additionally, (Raza et al., 2015) state that increasing temperature is also accompanied by increasing precipitation in this region. By analyzing the trends of past years, it became evident that winter season temperatures have increased with time in this region.

Global studies reveal the implications of high and low temperatures on road infrastructure. Low temperatures in the region usually cause transverse cracking but contrary to this, increased average temperature leads to longitudinal and alligator cracking. This impacts the performance of the road and require quicker repairs and maintenance. The dramatic swings in temperature, with extreme heat followed by sudden cold spells, can cause roads to crack and buckle. This weakens the pavement and makes it more susceptible to further damage from other factors (Stoner et al., 2019).

Another international research (Barbosa et al., 2023) displays the effects of climate change extremes on the road pavements, based on the information obtained from The World Road Association, as shown in the table 4.

Table-1. Effects of Climate Change Extremes on Road (Barbosa et al., 2023)

| Extreme Occurrences | Relevant Effects on Road Pavements |
|---|---|
| **Temperature top range are increased** | - Flexible pavements experience a higher occurrence of rutting<br>- Bituminous pavements display a sign of bleeding<br>- Bituminous layers undergo accelerated aging<br>- Higher demand for maintenance<br>- Higher risk of occurrence of bushfires |
| **Decreased Temperatures and augmented freeze-thaw occurrences** | - The bearing capacity decreases<br>- Bituminous pavements may suffer from cracking, raveling and the formation of potholes<br>- The demand for pavement maintenance, including deicing, rises |
| **Higher frequency of storm and higher rainfall intensity** | - Water level tends to rise<br>- Road drainage systems become inadequate, resulting in flooding<br>- Bearing capacity is diminished<br>- Cracking and permanent deformation may occur<br>- Higher risk of slope failure<br>- Risk of road closure and loss of efficiency in transportation service |
| **Increase in Droughts** | - Surface roughness increases<br>- Subgrade moisture tend to decrease |

It is evident that the higher average temperatures and extreme temperature events can damage or weaken the structural integrity of transport networks, including bridges and road surfaces. These extremes in the weather caused by temperature changes has lead to negative impact on the social infrastructure in KKH region (Aslam et al., 2023).

***Road Damage by Glacial Lake Outburst Floods (GLOFs)***

Glacial Lake Outburst Flood is very common in the Northern areas of Pakistan. These lakes are formed at the margins of glaciers along the lateral moraines. The lateral moraines create a linear high which mostly runs parallel to the direction of the glacial drift. This creates a linear depression between the lateral moraine and the outcropping rocks forming a glacial lake. Climate change has resulted in rising temperatures, which

prompts glacial melting and formation of glacial lakes. The northern area of Pakistan has about 2420 glacial lakes in the KKH region, as determined by remote sensing. About 52 lakes are known to be potentially dangerous. When water in these lakes exceed beyond a limit, it develops a pressure on the retaining walls of the lake. As a result, an outburst will take place from the weakest bank and the water flows down, carrying debris and boulders with it, destroying roads and bridges in its way.(Chaudhry et al., n.d.)

In the last few decades, there have been 20 severe GLOF events in Pakistan which led to the loss of life and infrastructure. Five events of GLOFs were reported alone in 2008 from the Gojal village of Hunza valley causing considerable damage to the infrastructure of these areas.

These glacial lakes are the potential threats to all the ongoing developmental projects towards the near downstream area of the lakes, including bridges and roads. There are numerous reported events as evidence of GLOFs due to climate change in the region, leading to severe destruction.

Damage to roads and other infrastructure was evident by the heavy flood in Ghulkin in 2008. Ghulkin Glacier is an active mountain glacier, where an outburst occurred in the terminal moraine, flowing with debris and rocks. Report state that this climate change driven GLOF also caused localized damage to the Karakoram Highway in the upper Hunza Valley. Similarly, flood in Hussaini also inflicted damage to the bridges, causing it to be blocked for 4 days. As a result, people had to carry their good manually leading to physical and metal fatigue. (Ashraf et al., 2012)

On 7 May 2022, extreme heat waves caused by climate change seemed to trigger the glacial outburst of the lake formed from the Shisper Glacier in the Hunza Valley of Karakoram Range. It was this event which dramatically swept away the Hassanabad Bridge in Pakistan, one of the worst bridge destruction noted until the present time. It had a high peak discharge of approximately 280 m3/s at the Hassanabad river gauge,14 times greater than the annual mean discharge of 20 m3/s, and a new record for this site (Bhambri et al., 2020)

Retreating glaciers and warming permafrost are associated with destabilised slopes. They can lead directly to landslides, or reduce the strength thresholds for, and the likelihood or size of, slope failures due to earthquakes or storms, which trigger most of the more destructive landslide events. For example, a dangerous landslide occurred on January 4, which blocked the Hunza River in the central Karakoram and probably involved destabilisation by changing moisture and temperature conditions in the slopes (Hewitt, 2010)

The Northern region of Pakistan, particularly the Gilgit Baltistan region, is currently under development of road infrastructure with the help of China-Pak Economic Corridor. However, the Karakoram Highway is facing implications of climate change in the form of heavy rainfall, snowfall, resulting in economic problems such as traffic and inefficiency of transporting materials. A recent instance of 28 July 2021 showed that heavy rain and snow/ glacier melt caused disruption in the KKH. Data reveals that 200 vehicles and around 400 people were stranded. The damage to roads is indirectly harming the socioeconomic conditions of the region.(Ali et al., 2021)

**Adaptation Strategies**

There are several ways overcome the adverse impacts of GLOFs by taking actions for flooding that occur as a result of glacial outburst.

1. Install flood monitoring and early warning systems to provide advanced notice of potential flooding
2. Construct barriers, levees, and floodwalls along rivers and coastlines to help contain floodwaters.
3. Raise the level of roads, bridges, buildings, and other critical infrastructure above expected flood levels.
4. Make infrastructure water-resistant and able to withstand flooding.
5. Upgrade storm drains, culverts, and ditches to increase drainage capacity.
6. Construct holding ponds and retention areas to temporarily store floodwaters.
7. Educate communities on flood risks and preparedness.

**Conclusion**

This review provides a detailed analysis of the effects of climate change on agriculture and road infrastructure in the Northern Areas of Pakistan, highlighting the vulnerabilities of this ecologically diverse region, nestled within the grandeur of the Karakoram, Himalayas, and Hindukush ranges, and susceptible to disruptions induced by changing climatic patterns.

The agricultural sector, which is a vital component of the region's economy, faces complex challenges. The impacts on major crops such as wheat, maize, and sugarcane vary across different sub-regions, highlighting the intricate nature of agricultural patterns. For example, while the high mountain ranges like Chitral may experience increased wheat yields, the plains of Peshawar may face potential reductions, which could affect farmers' livelihoods and exacerbate poverty levels. Climate change-induced phenomena, including erratic rainfall patterns, floods, and attacks from pests and diseases, compound the predicament faced by local farmers. Furthermore, a 2012 study from the University of Agriculture in Faisalabad confirms the negative and irreversible consequences of climate change on agriculture in the Northern Areas.

Temperature fluctuations, particularly during winters, are reducing the growing season of crops, leading to lower yields and difficulties in livestock rearing. Rising temperatures have also resulted in shortened reproductive phases for crops, longer winters, increased disease prevalence among crops, and delayed sowing and harvesting periods. The lack of awareness and continued deforestation contribute to overall temperature increases, causing glacial melt and flash floods, which further impact the agricultural landscape.

Local farmers are adapting to these challenges by implementing strategies such as planting multiple crops in the same fields and delaying wheat sowing. However, challenges persist, necessitating holistic approaches and increased awareness to address them.

The impacts of climate change extend beyond agriculture to the critical realm of road infrastructure. In Pakistan's northern areas, transportation plays a pivotal role in people's lives. However, the non-resilience of roads and pavements to climate change poses significant challenges. Increased temperatures, recurrent landslides, and the specter of Glacial Lake Outburst Floods (GLOFs) are contributing to the deterioration of road infrastructure, leading to economic costs and disruptions in transportation

systems. Glacial melting, GLOFs, and landslides are causing severe damage to roads and bridges, hindering socioeconomic development.

As the region undergoes infrastructure development, exemplified by the China-Pakistan Economic Corridor, the implications of climate change on road infrastructure are acutely felt. Heavy rainfall, snowfall, and glacier melt, as witnessed in the recent events of July 2021, result in traffic disruptions and inefficiencies in transporting materials, indirectly impacting the socioeconomic conditions of the region.

In summary, the Northern Areas of Pakistan are facing complex challenges due to the intricate interplay of climate change on agriculture and road infrastructure. Urgent and concerted efforts are needed to develop and implement comprehensive climate adaptation strategies, fostering sustainable practices, and building resilient infrastructure to mitigate the multifaceted impacts of climate change on this ecologically sensitive region.

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a

b

# POWER GENERATION FROM IRRIGATION CANALS IN PUNJAB PAKISTAN

**By**

**M. H. Mahu, PhD[1]**

## Abstract

Small hydropower projects on irrigation canals have been constructed with total installed capacity of 19.88 MW in Punjab Pakistan. The scope of work comprises of construction of a diversion power channel, powerhouse, gated spillway, tailrace, raising of existing embankments, excavation of canal, installation of sets of double regulated horizontal shaft Kaplan turbines, sets of digital electro hydraulic governors, sets of draft tubes with hydraulically operated roller gates and sets of power intake trash racks and stop logs. Two plants at Pakpattan on Pakpattan canal and at Marala on Upper Chenab canal are successfully in operation since 2017 and have been connected to national grid. Chianwali project is completed and has been connected to national grid in June 2023. Deg outfall project has been built in 2017. During its initial operation, the spillway was settled downed. The hydraulic and structural design of the project was reviewed and investigated. The spillway has been planned to reconstruct and project shall be connected to national grid in March 2024. Low head technology is used due to less drop available up to 4m. The cost per megawatt is about US$ 4 million. The paper covers unique features about design and construction of four hydropower projects which are beneficial to the humankind especially hydropower engineering profession.

**Keywords:** Small hydropower, irrigation canal, model study, Upper Chenab canal, Pakpattan canal

## 1. Preamble

Prime object of irrigation canals is to supply water to farms fields for agriculture production. However, these canals are used as a bye product for energy production. Four small hydropower projects having heads up to 4 m have been constructed on irrigation canals in Punjab Pakistan. The Pakpattan hydropower project achieved commercial operation in February, 2017. The project was completed at a project cost of US$ 10.64 million (Pak rupees 1787 million). The plant is successfully in operation and has been connected to national Grid. Marala hydropower project has been completed at a project cost of US$ 30.90 (Pak Rupees 4545 million and achieved commercial operation in November 2018. Chianwali hydropower project has been completed at a project cost of US$ 21.14 million (Pak Rupees 3568 million) and achieved commercial operation in June 2023. Deg Outfall hydropower project has also been partially completed at a project cost of US$ 16.41 million (Pak Rupees 2508 million) and shall achieve its commercial operation date on March 2024. Coronavirus Covid-19 Epidemic has also caused adverse impact on the progress of Chianwali and Deg Outfall hydropower projects. This paper express the details of design and construction aspects of one hydropower power project on Pakpattan canal and three hydropower projects on Upper Chenab Canal in Punjab Pakistan. The location map of four hydropower projects is shown in Figure-1.

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## 2. Projects Layouts

The major principles considered for design of projects layouts are (a) no adverse influence on the safety and operation of the canal (b) the design flow capacity of canal is not impaired (c) convenient for construction (d) feasible in technology (d) convenient for operation and management (e) hydraulic aspects of the curves of headrace and tailrace channels is satisfactory. The details of each layout plan is described below.

### 2.1. Pakpattan Hydropower Project

A low head run-of-canal Pakpattan hydropower project with installed capacity of 2.82 MW has been constructed in district Pakpattan on Pakpattan canal which offtakes from Sulemanki barrage with the design head discharge of 186.75 m3/s. The layout of project is planned in such a way that the main canal was continue flowing without obstruction, powerhouse and spillway as an adjoining structure are constructed on the right side of the main canal in power channel at Rd 114+636. A connecting headrace and tailrace channels are formed on the right side of the main canal with the design capacity of 112.57 $m^3/s$. The plant has two units and design discharge of each unit is 40 $m^3/s$. The total design discharge of the plant is 80 $m^3/s$. The powerhouse is constructed at Rd 114+636 by combining heads of two falls to achieve better head between two falls at Rd 112+350 and fall Rd 124+950. A rated net head of 4.20 m has been found suitable for determination of installed capacity. The net head and power potential are computed at different discharges ranging from 12 $m^3/s$ (minimum discharge of one turbine) to 112.57 $m^3/s$. The installed power potential and annual energy production have been computed as 2.82 MW and 21.67 GWh with plant factor 84.38%. Plant factor is the ratio of average generated power by the plant to the maximum power that could have been generated for a given time period. As this power house is constructed over the perennial existing irrigation canal system so the annual maintenance closure period is deducted for the energy calculation. The layout plan of Pakpattan hydropower project is shown in Figure-2.

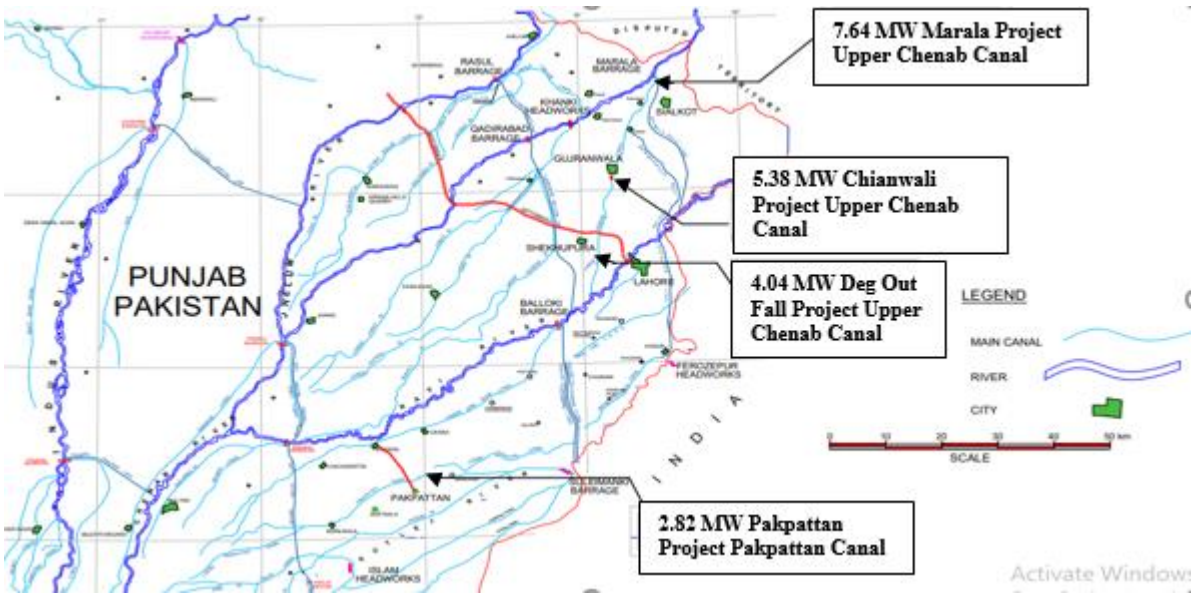



**Figure-1:** Project locations map of hydropower projects on irrigation canals in Punjab Pakistan

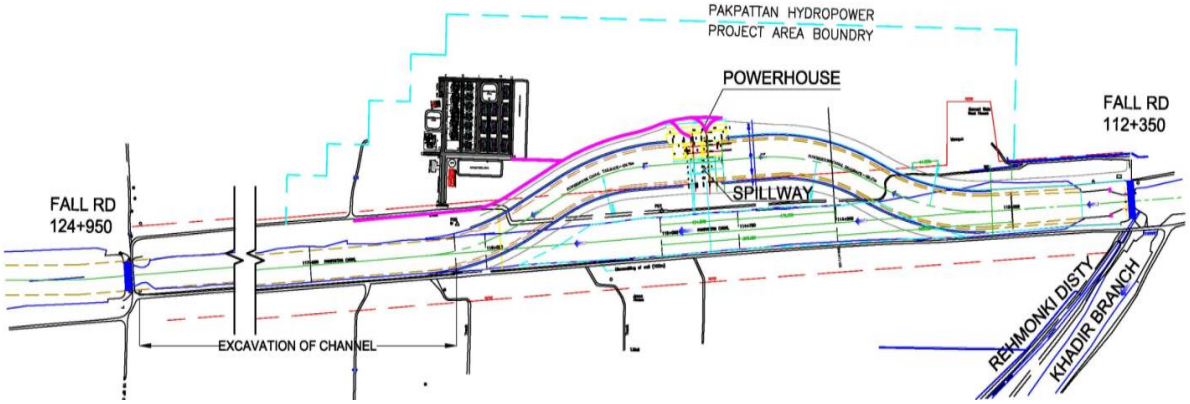



**Figure-2:** Layout Plan of Pakpattan Hydropower Project

## 2.2. Marala Hydropower Project

A low head run-of-canal Marala hydropower project with installed capacity of 7.64 MW has been constructed in district Sialkot on Upper Chenab Canal downstream its head regulator at about Rd 2+850 in bypass arrangement. The site is located about 305 m downstream of the main Head Regulator of canal and about 25 km north of Sialkot city. The project uses the fall at diversion canal to produce power output at rated discharge of 420 $m^3/s$ and electricity production of 43.37 GWh per year at plant factor 65.56%. The project layout arrangement consists of a gated spillway at Rd 3+155 in the existing canal with designed discharge of 555 $m^3$ /s and a powerhouse at Rd 3+436 in bye-pass power channel on right side of canal with a design discharge of 420 $m^3$ /s and having four units. As per longitudinal section of canal, the maximum designed discharge of canal at Rd 0+000 is 477.14 $m^3/s$. The higher discharge for spillway capacity was fixed on the basis of future irrigation requirements. Net head and power potential are computed at different discharges ranging from 31.5 $m^3/s$ (minimum discharge of one turbine) to 477 $m^3/s$. A rated net head of 2.16 m has been found suitable for determination of installed capacity. The layout plan of Marala hydro project is depicted in Figure 3.

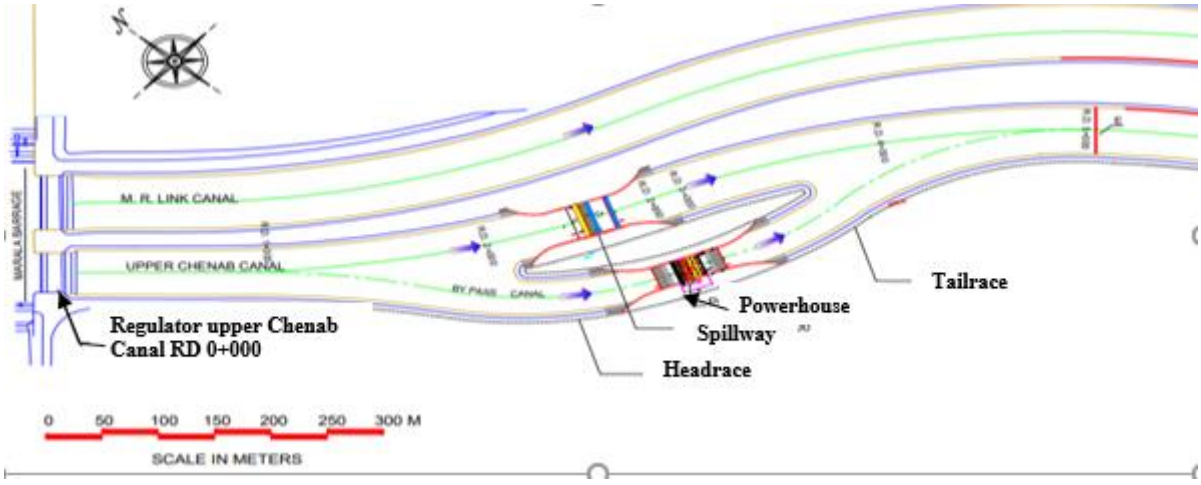



**Figure-3:** Layout Plan of Marala Hydropower Project

## 2.3. Chinawali Hydropower Project

A low head run-of-canal Chianwali hydropower project with installed capacity of 5.38 MW has been constructed in district Gujranwala on the Upper Chenab Canal between Rd 129+000 to Rd 133+000. The powerhouse is constructed at Rd 131+250 having

two units with unit discharge 75 $m^3/s$ and design head 4.2 m. The plant shall generate average annual energy of 28.82 GWh at plant factor 59.88%. The power house has been constructed on the diversion channel to save the implementation time while sub-station and operation and maintenance colony on the right side of the canal. There are two falls structures at Rd 128+000 and Rd 164+000 which was combined at Rd 131+117 to have the required head to run the power plant. A feeder channel has been constructed in the right of way of the main canal to feed the distributaries in Sheikhupura, Akbar and Harpoki at Rd 163+000. The powerhouse is located at RD 131+117 about 600 m downstream of existing fall structure at RD 128+000 towards the left bank of the canal to make maximum use of the existing road for construction purposes. The powerhouse and spillway are placed adjacently along the same axis. An access road is realigned to pass over the powerhouse draft tube and spillway to connect the existing right bank road. Construction of feeder canal and associated structures to ensure the required discharge for three off taking distributaries downstream of Powerhouse was also part of the project. The layout plan of Chianwali hydropower project is shown in Figure 4.

### 2.4. Deg Outfall Hydropower Project

A low head run-of-canal Deg Outfall hydropower project with installed plant capacity of 4.04 MW has been constructed in district Sheikhupura in by-pass arrangement opposite Rd 282+225 of Upper Chenab Canal. Upper Chenab Canal (Main Line Lower) is controlled from Bombanwala head regulator. The designed discharge of the head regulator is 315 $m^3/sec$. A number of fall structures exist along this canal where hydropower projects can be developed. The project mainly consists of combination of two falls Rd 266+000 and Rd 283+100 to utilize the head for energy output. A power canal in a bypass arrangement situated at right side of canal between Rd 280+400 and Rd 283+819 and the power house was constructed midway opposite Rd 282+225 of canal. It includes intake section, gated spillway, power house and tail race section. The bed level and the embankment of the power canal upstream of power house was constructed to the existing level of canal upstream of the fall structure at Rd 266+000. The power canal downstream of the power house was designed and constructed to the bed level of canal at Rd 283+819 in accordance with the bed level downstream of fall structure at Rd 283+100. The plant has two units with design discharge 120 $m^3/s$ and shall generate average annual energy of 26.46 GWh at a plant factor of 74.52%.The layout plan of Deg Outfall hydropower project is shown in Figure 5.

## 3. Civil Works

Major scope of civil works in these four hydropower projects include construction of power canal works in bypass arrangement, construction of tail race canal works in by-pass arrangement, raising of existing canal embankments from upstream of powerhouse location according to remodeled cross sections, excavation of canal from downstream of powerhouse according to remodeled cross sections, construction of new district road bridges and village road bridges on canals, gated spillway structure with service bridge, construction of protection works, powerhouse buildings and ancillary structures including machine hall, control building, intake and outlet bays with cut-offs, and retaining walls in power canal etc.

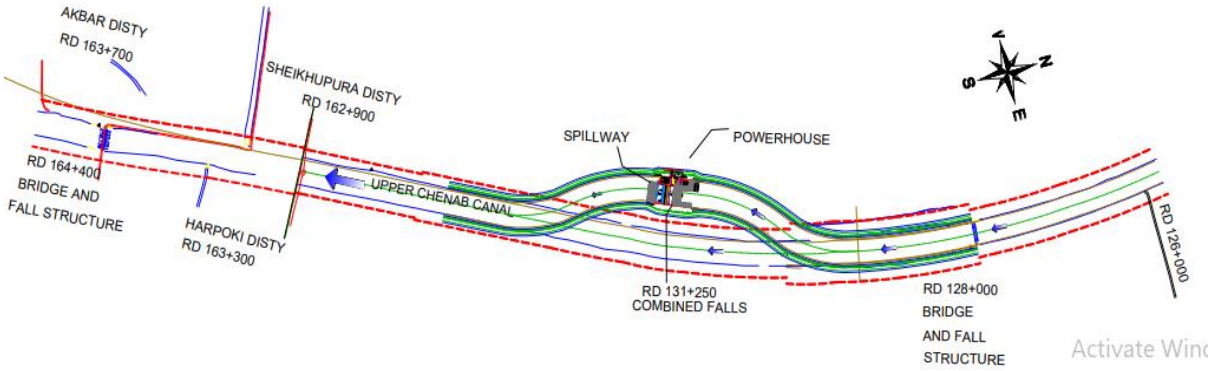



**Figure-4:** Layout Plan of Chianwali Hydropower Project

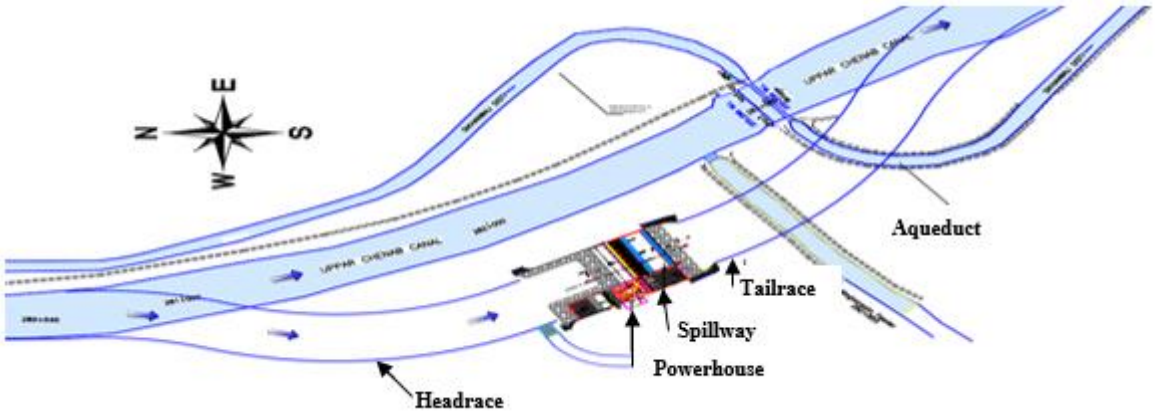



**Figure-5:** Layout Plan of Deg Outfall Hydropower Project

## 4. Power Potential and Annual Energy

Power potential and annual energy production are computed using the following basic formulas.

$$P = \eta\,(\gamma . Q . H_{net})/1000 \qquad (1)$$

where P is the Power Potential in MW, $H_{net} = H_{gross}$ – Losses in powerhouse and $H_{gross}$ is the difference of constant HWL and variable TWL, γ is the unit weight of water, three types of efficiencies are involved in the above formula which are as followings:

$$\eta_{total} = \eta_{turbine}\ x\ \eta_{generator}\ x\ \eta_{transformer} \qquad (2)$$

$$\text{Annual Energy Generation (GWh)} = P \text{ x (No. of operating hours in year)}/1000 \qquad (3)$$

The turbine efficiencies under different scenarios of discharge availability for power have also been computed while the generator and transformer efficiencies are taken as fixed i.e., 0.96 and 0.98 respectively. These are estimated efficiencies which are used for annual energy production. The losses play a very important role in the electrical machine design. To achieve an optimum design, the losses must be minimum and accurately predicted to guarantee the highest efficiency of the machine at a minimum cost. The efficiency of the generator was given in terms of the standards of IEEE115, which is recognized and adopted in GE and most of the international manufacturers of generators. The actual efficiency of the generator mentioned in section 10 of the paper is guaranteed. 11 KV three phase power transformer is designed in compliance to IEC60076.

## 4.1. Energy Production

The gross head across for the proposed powerhouse depends on the difference of Head Water Level (HWL) and Tail water Level (TWL). The TWL in downstream reach of powerhouse is not controlled and tail water rating curve is used to assess the tail water level corresponding to range of discharges. However, the HWL depends on the operation of canal reach upstream of powerhouse. A constant HWL at the canal's designed FSL upstream of powerhouse is considered while the daily tail water levels for downstream of powerhouse is estimated using discharge rating curve of tailrace just downstream of powerhouse. The downstream releases of powerhouse are adjusted on daily basis to keep the HWL constant throughout the year.

## 4.2. Head Losses in Powerhouse Structure

The head losses have been estimated for the entire water way up to the turbines. These include the local losses in existing fall, at ends and transitions in headrace, in trash racks, in gate / stop log slots, etc. The friction losses in the headrace channel have been subtracted from the designed water level at upstream of fall structure using the remodelled bed slope of canal. Head losses are estimated as per criteria given in USBR's design of small dams and Layman's Guidebook and Guidelines for Hydraulic Design of Small Hydro Plant by Indian Institute of Technology, Roorkee. Due to limited length of the paper, calculations are not made part of the paper. However, head losses in powerhouse are summarized in Table-1. Following types of head losses in the powerhouse have been considered.

### 4.2.1. Losses on Upstream of Powerhouse

1. Entrance loss due to contraction (from headrace to upstream approach of powerhouse)
2. Slope loss in upstream approach of powerhouse (due to friction)
3. Entrance loss due to contraction (from upstream approach to intake bay of powerhouse)
4. Trash rack loss
5. Entrance loss due to vertical contraction (at start of pressurized flow)
6. Loss due to miscellaneous uncounted factors (max. of the above 5 number losses)

### 4.2.2. Losses on Downstream of Powerhouse

7. Exit loss due to expansion (from downstream exit of powerhouse to tailrace)
8. Slope loss (from outlet bay to downstream exit of powerhouse)
9. Exit loss due to expansion (from draft tube to outlet bay)

**Table-1:** Head Loss Estimations

| Project | Disch. ($m^3/s$) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Total H. loss (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pakpattan** | 80 | 0.010 | 0.003 | 0.004 | 0.045 | 0.001 | 0.045 | 0.023 | 0.042 | 0.013 | 0.186 |
| **Marala** | 420 | 0.007 | 0.006 | 0.029 | 0.056 | 0.001 | 0.056 | 0.007 | 0.021 | 0.004 | 0.187 |

## 5. Hydraulic Model Study

Physical model of four projects was constructed with geometrical scale of 25 at hydraulic field station Nandipur, Gujranwala. The purpose of the model study was to determine the discharge capacity of proposed powerhouse and spillway, gated and un-gated flow conditions through spillway, flow conditions in headrace and tailrace to establish optimal curvatures, water levels in headrace and tailrace at design discharge of powerhouse, stability of stone pitching and apron at various flow conditions and when sudden shut down of powerhouse occurs creating surge in headrace, extend/height of surge and its impact on head regulator along with its celerity and normal functioning of existing irrigation system after construction of powerhouse. Due to limited length of the paper, it is difficult to explain all the details of the model study. However, the results of model study for Marala hydropower project are presented here. After model verification, the experimentation was made under different 10 tests. The position of spillway was tested at two locations at RD 3+155 and RD 2+756. After hydraulic performance of spillway and power house at two locations, the location of spillway at RD 3+155 was found suitable for power house in all operational stages of turbines with the following conclusions.

- Powerhouse passed the design discharge 420 $m^3/s$ with uniform distributions through four turbines with upstream water level as 246.74 masl in the headrace channel
- The flow all along the banks of headrace channel remained friendly without showing any negative impact on the embankments of the channel and no eddy was formed in front of powerhouse
- The island between powerhouse and spillway diverts the required flow for power house according to the design discharge without having erodible velocity along its bank due to modified elliptical nose of island
- The surge height of about 0.95 m was generated due to sudden shut down of all units of power house and its intensity reduced as it travelled towards the head regulator of UCC subsequently opening of spillway gates, it is recommended to keep the free board 1m excess of this surge, 2m from normal water level.
- In the construction, all recommendations of the model study were implemented.

## 6. Hydrology

The flow duration curve of Pakpattan canal at powerhouse location Rd 114+636 of Pakpattan hydropower project indicates that for each year of the part of historical period from 1991 to 2000, 80 $m^3/s$ remained available for more than 30% of time (110

days) while for each year of the historical period from 2001 to 2010, 80 $m^3/s$ remained available between the ranges of 25% of time (91 days) to 0% of time. Upper Chenab Canal is a perennial canal with variation in discharges in Rabi and Kharif season and remained closed normally from December 26 to January 14 for annual maintenance purposes. The summer and winter seasons have been considered from 16 April to 15 October and 16 October to 15 April respectively. The analysing the 28 years data (1984 to 2011) shows that 420 $m^3/s$ remained available for about 3.5% of time. The selection of high value of discharge was based on future needs of irrigation of canal. The flow duration curve of Upper Chenab Canal at powerhouse of Chianwali hydropower project indicates that nine years data (2000 to 2009) shows that 150 $m^3/s$ remained available for about 11% of time. The flow duration curve of Upper Chenab Canal at powerhouse of Deg Outfall hydropower project indicates shows that 120 $m^3/s$ remained available for about 17% of time based on the flow data (2000 to 2009).

## 7. Spillway and stilling Basin

Spillway is designed on the full supply discharge of the canal in that reach so that in case shut down of powerhouse, the whole water can be passed through the spillway. In addition, to provide sufficient capacity, the spillway is hydraulically and structurally adequate and is located so that spillway discharges do not erode or undermine the downstream toe of the structure. For design of stilling basin on these hydropower projects, several factors such as; nature of foundation, approach Froude number, impact angle of flow with respect to stilling basin floor, tail water level and economic considerations have been considered. For interest of readers, only technical details are included in the paper for spillway and stilling basin of Marala hydropower project.

### 7.1. Spillway

The gated broad crested spillway is provided for 555 $m^3/s$ which is about 16% higher discharge of the full supply discharge of Upper Chenab Canal. Energy dissipaters are provided to dissipate the energy of the falling water at the bottom of spillway and various essential factors required for optimal performance of spillway were considered. The Spillway has nine bays each 7.62 m long and has eight piers each 1.50 m wide. The spillway crest level of 243.688 masl has been adopted after a series of trials with higher and lower elevations. Higher crest elevation results in making the crest length more than 68.580 m. A number of crest widths have been studied. It has been found that a total crest width of 80.579 meter (9 bays of 7.62 meter width and 1.50 meter wide piers) and broad crested shape is capable of passing the maximum design discharge. The resulted maximum surcharge level is 246.744 masl. Upstream chute is provided with slope of 1V to 2H. Width of the crest is provided 2.25 times head on crest to ensure the crest to behave as broad crested. Downstream chute is provided with slope of 1V to 2H. The broad crested spillway is designed according to the following weir formula.

$$q = \mathrm{C}_o \mathrm{H}_o^{3/2} \qquad (4)$$

Where q is the discharge per unit width in $m^3/s/m$, $H_o$ is the total head over the weir (m), $C_o$ is the Coefficient of discharge. The Coefficient of discharge, $C_o$ for the broad crested spillway is adopted as 1.8 (SI system) and 3.09 in Foot Pound System. The discharge capacity of the spillway was vetted by the physical hydraulic model study results and Coefficient of discharge was also verified by the model study.

## 7.2. Stilling Basin

The dissipation of energy has been achieved by means of stilling basin. In the stilling basin, the supercritical flow from the spillway is reduced to sub critical flow by a hydraulic jump. The formation of hydraulic jump in the stilling basin leads to dissipation of excess energy. Stilling basin has been designed as USBR Type IV basin. For design discharge, the water depth at the end of the chute is 0.61 m and conjugate depth is 3.16 m while the Froude Number before the jump is 3.99. Chute blocks of 0.61 m wide, 1.22 m high at spacing of 1.52 m have been provided at the start of stilling basin to reduce the length of jump. The stilling basin is 21.03 m long. At the end of stilling basin there is proper end sill which is followed by inverted filters. The elevation of the cistern is 240.335 masl and the tail water level is 244.659 masl. The computed dimensions of spillway and stilling basin were finalized by the Model study results.

## 8. Head Race and Tail Race Channels

The trapezoidal power channel section with side slope protected with stone and bed unprotected is provided to ensure the stability of side slopes under different operational conditions. The headrace channel is designed for stone side protections with opting the composite Manning's 'n' as 0.0263. The embankments of the canal are made with compacted earth fill with 1v:1.5h inward & outward slopes. Water passes through the spillway or releases from the powerhouse is carried back into canal through tailrace channel. The hydraulic design parameters of headrace and tailrace channels was finalized by the hydraulic model study results conducted at Hydraulics field station Nandipur.

## 9. Powerhouse

The powerhouse consists of one unit block with required length and one unloading / erection bay. The unloading / erection bay are located at the right side of powerhouse. The powerhouse in the direction of flow is composed of intake structure, powerhouse and draft tube. Fixed trash rack is installed at intake to prevent debris from entering into water passage and turbine. Stop log gates operated by upstream gantry crane are arranged at intake. Powerhouse includes gallery, operating floor and superstructure. The access gallery runs through the whole unit blocks for the convenience of inspection and maintenance. The width and height of Powerhouse are fixed by unit layout and lifting height of equipment. In case of Pakpattan, the powerhouse length is 18 m and 30 m width. In case of Marala project, the powerhouse consists of one unit block with total length of 54.43 m and one unloading / erection bay with total length of 23.00 m. The superstructure includes columns, concrete crane girder and roof steel frame.

## 10. Hydro electrical and Mechanical Equipment

In case of Pakpattan hydropower project, the two sets of horizontal Pit type tubular Kaplan turbines are provided each with rated output of 1.505MW at rated head of 4.2m and rated flow of 40 $m^3/s$ complete with all auxiliary equipment including regulating gear, turbine casing, guide vanes, thrust and guide bearings, etc. The diameter of turbine runner is 2.6m. In case of Marala project, four sets of horizontal Pit type tubular Kaplan turbines, each with rated output of 2.022MW at rated head of 2.16 m, rated flow of 105 $m^3/s$, complete with all auxiliary equipment including regulating gear, turbine casing, guide vanes, thrust and guide bearings, are provided. The diameter of turbine runner is 4.9 m. In case of Chianwali project, two sets of double regulated horizontal shaft Kaplan turbines, each 2.8 MW, with a rated head of 4.2 m, rated flow

of 75 $m^3$/s complete with all auxiliary equipment including regulating gear, turbine casing, guide vanes, thrust and guide bearings are provided. In case of Deg Outfall project, the hydro-mechanical equipment comprises of two sets of double regulated horizontal shaft Kaplan turbines, each 2.12 MW, with a rated head of 4.0 m, rated flow of 60 $m^3$/s complete with all auxiliary equipment including regulating gear, turbine casing, guide vanes, thrust and guide bearings. When turbine is running at rated speed in the range of operating head and flow, the turbine efficiency and output is guaranteed. In case of Pakpattan, at rated head 4.2 m, turbine efficiency is 91.96%, generator efficiency is 96.03%, and turbine output is 1505 KW. In case of Marala, at rated head 2.16 m, the turbine efficiency is 91.76%, generator efficiency is 96.07% and turbine output is 2022 KW.

## 11. Construction Works

The implementation of the Pakpattan hydropower project covered duration of 885 days which includes mobilization, detailed design, model study, construction / procurement of plant and equipment, transportation, site installation, testing and commissioning etc. The contractor took extra time of 664 days to complete the project till commercial operation date (COD). The delayed was due to lack of resources by the Contractor. The contractor has been penalized by the employer due to late completion of the project. The matter is under arbitration stage. Photo 1 shows the completed view of spillway and powerhouse of Pakpattan project. The civil quantities executed on the project are concrete in powerhouse 21500 $m^3$ and in the spillway 4457 $m^3$, excavation 1917 $m^3$, filling 2134 $m^3$ and steel 1645 ton. The construction completion time in Marala project was 900 days but it was completed in 1122 days. The delayed was due to many reasons which includes lack of resources by the Contractor, review of design of Marala hydropower project. Photo 2 shows the completed view of spillway and powerhouse of Marala project. The civil quantities executed on the project are concrete in powerhouse 46000 $m^3$ and in the spillway 10000 $m^3$, excavation 3900 $m^3$, filling 4500 $m^3$ and steel 375 ton.





Photo-1: View of Pakpattan project looking from downstream Photo 2. View of Marala project looking from downstream

## 12. Collapse of Spillway of Dag Outfall HPP

Deg outfall project has been built in 2017. Its spillway with design discharge of 120 $m^3$/s having seven bays with radial gates was constructed as safety valve for power house to pass excess water in case of shut down /surge. After the substantial completion of project, its spillway was put in trial operation by diverting the canal flow on 2 February 2017. On 17 February 2017, all of a sudden the spillway collapsed /settled down and suspended supply of irrigation water to huge chunks of agriculture land in several surrounding areas. Photo 3 and Photo 4 depicts the view of settled spillway. The canal was closed on emergency basis to avoid the further collateral damage of the allied infrastructure.

## 12.1. Reasons of failure of spillway

A concrete separation divide wall separates the spillway from powerhouse in the direction of flow. This divide wall was extended upstream of power house to form inlet bay and also extended in the downstream side. The pit of powerhouse was excavated deeper than the crest of spillway to accommodate the Kaplan turbine as per design. It was observed and investigated that alongside the divide wall on spillway side, the compaction was not done properly and replacement of local material with good quality material as per specification was not made. When water was released in the head race channel, two scour holes were developed by the formation of swirls just 40 m upstream of spillway and 74 m downstream of spillway on its right side from plant axis due to loose strata alongside the divide wall. A week zone alongside the separation wall from upstream towards downstream underneath the spillway was found after detailed soil and geotechnical investigation. The failure of spillway occurred due to slippage of sub soil into the scour hole by water pressure and ultimately undermined of the foundation soil beneath the spillway.

## 12.2. Remedial measures

The failure of spillway created serious doubts on the credibility of design & quality assurance of the Deg Outfall Project and other hydropower projects which were under construction at that time (Chianwali and Marala). The hydraulic and structural design of the all four projects were reviewed and investigated. A detailed condition survey was carried out to evaluate the condition of remaining structure and also for overall project rehabilitation. The contractor took responsibility for its failure and made rehabilitation works at its own cost. The model study was again done with the modification. The spillway was separated from powerhouse by well compacted earthen island with concrete retaining wall around it. All these activities including design review took considerable time and commercial operation date revised with the approval of Employer. The construction work is near to complete.



Photo-3: View of settled spillway looking from upstream



Photo-4: View of settled spillway looking from downstream

## 13. Dispersal of Power

For the dispersal of power, Pakpattan project has been connected through single circuit 11 KV overhead transmission lines with national grid power system at Pakpattan city with 66 KV sub-station at a distance of about 12km. The transmission line is designed as per grid specifications and standards. The regulator (NEPRA) has approved tariff at US cents 7.1757 per kWh (Rupees 7.3855 per KWh). The generated energy is being evacuated to Pakpattan grid station through a pre-COD sale agreement signed with Multan distribution co. Till now, the units generated as of June 30, 2022 are about 53.32 GWh. For the dispersal of power, the Marala project has been connected through single circuit 11 KV overhead transmission lines with national grid power system at Marala head works 66 KV sub-station at a distance of about 2km. The regulator (NEPRA) has approved tariff at US cents 8.5492 per kWh (Rupees 8.7997 per KWh). The units generated till June 30, 2022 are 87.21 GWh. The transmission line of both Chianwali and Deg Outfall projects have also been completed. The regulator has approved Tariff for Chianwali and Deg Outfall as US cents 10.7410 per kWh (Rupees 11.0561 per KWh) and US cents 8.6114 per kWh (Rupees 8.8640 per KWh) respectively.

## 14. Problems during construction

In case of Pakpattan, one of the problems during the construction stage was the model study conducted by the Research institute at Nandipur. The detailed design was made by the contractor and vetted by the Punjab Irrigation Department. It took considerable time to vet the model study. The other contract problem faced during construction stage was the change of manufacturer of equipment for the plant. Due to poor response and week process of providing information for the change of manufacturer as per bank requirements, the delay was happened to finalize the manufacturer of equipment of the plant. In case of Marala, during construction, one of the major problems was dewatering of construction area of power house, inlet bays and outlet bays. It was contractually required to keep water table 1m below excavation line of power house. About 68 number water pumps of 0.0354 $m^3/s$ capacity each were installed on project area to keep ground water level down enough from bottom line of excavation. These were worked 24 hours a day throughout the project duration. During construction when inlet slab and outlet bays slabs have been constructed and power house partially completed, the site in charge thought to shut off all the pumps, eventually, due to /uplift pressure, the inlet bays slab were lifted up and water was oozed out from broken joints. Water stop all along the upstream retaining walls inside the upstream inlet bays were worn. Same situation was also happened on outlets bays. Different remedial options were considered to rectify the problem. The contractor put an overlay of concrete of 0.6m over the already poured slab of inlet and outlets bays to increase the dead weight at his own cost. Other major cause of delays were delay in model study, contractor general management issues, general hindrances in canal closure related works, single contractor on all four projects.

## 15. Lessons Learnt

The tasks for pre-construction stage i.e., appointment of consultants, review of feasibility studies, preparation of tender level designs / tender documents, International Competitive Bidding for EPC/Turnkey Contracts, technical and financial evaluation of bids was completed under the Asian Development Bank procedures. However project was delayed due to delay in approval project by upper forums and loan signing, time taking procedures of bank and interdepartmental approvals, review

of policy/bank loan and site specific issues and change in designs during tender design stage. The layout with power house in bye-pass arrangement was finally implemented. Due to very low heads, the turbines are of large size with additional requirements of gear box to have the required speed for generators. The feasibility costs of plant and equipment of large size were estimated less as compared to the actual cost of very low head technology. The cost of land acquisition, resettlement and compensations, also increased as permanent land acquisition was considered essential due to site offices, colony and to avoid implications of EPC designs. The costs of employer's facilities were provided on lump sum basis. The consultants defined the employer's essential requirements during construction and operation which increased the project's cost.

## 16. Conclusions

The unique features of hydropower projects constructed on irrigation canals, design and construction aspects are presented in the paper. Based on the above, following conclusions are drawn.

- Tariff for small hydropower projects on irrigation canals ranges between US cent 7.10 to 10.70 per kWh
- Layout with power house on by-pass arrangement has significant advantage. Such layouts plans are free of diversion, associated canal closures and construction of power house, as a critical task
- Four hydropower projects are based on combination of canal falls at a distance of 7 to 10 km apart in order to have maximum water head to avail very low head technology. Due to elimination of the falls, remodeling of canals including huge excavations, filling, and reconstruction of new bridges, canal structures / regulators and feeder channels are the additional works which increased the cost.
- Cost per megawatt of very low head hydropower projects on irrigation canal falls in Punjab may not be compared with cost per megawatt of medium and high head hydel projects due to site specific issues, size of plant / economy of the scales
- Diversion channel length followed the standard design practice of hydraulics to avoid sharp curves with abnormally less radius for large canal
- Construction of diversion of a large canal with huge quantum of earth work involved significant cost and time as a critical task related to canal closure
- Construction of upstream and downstream coffer dams, protection works and constant watching for three years is also a cost component

## 17. ACKNOWLEDGMENTS

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# AIR QUALITY ASSESSMENT AND EFFICIENCY ANALYSIS OF JET PULSING DUST COLLECTOR IN SHOES MANUFACTURING INDUSTRY, BATAPUR, LAHORE PAKISTAN

**By**

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## ABSTRACT

Air pollution is a major problem that instigates multiple health problems in humans especially in the South Asian region. Air pollution Control and control of emissions from industrial sector should be taken seriously by the regulation bodies. The industries in Pakistan do not take into account the air quality and no regular assessments are carried out. Some industries have installed treatment plants to reduce the air emissions. In this study automatic Jet Pulsing Dust Collector type bag house is studied which is installed on boiler of 06 ton capacity using heavy fuel oil at shoes manufacturing industry, Batapur, Lahore Pakistan. Bag house is a device that is used to collect dust and purify the flue gases released in the air. The flue gas data of boiler before and after installation of bag house was monitored. The studied bag filter contained 30 bags made of imported glass fiber. The normal velocity at which the gas is passed through the bags is 0.4 to 1 $m^3$/minute. The results revealed that values of $O_2$ is 3.3%, $CO_2$ is 13.32%, CO is 388.68 mg/$Nm^3$, emission of NO is 192.72 mg/$Nm^3$, $NO_2$ is 30.45 mg/$Nm^3$, $NO_x$ 223.17 mg/$Nm^3$, SOx 2597.22 mg/$Nm^3$ with temperature value 196.9 ˚C before installation of bag house and values of $O_2$ (1.62%), $CO_2$ (6.48%), NO (121 mg/Nm3), $NO_2$ (14.21 mg/Nm3), $NO_x$ (135.21 mg/Nm3), $SO_x$ (1926.06 mg/$Nm^3$) and Temperature (135.7 ˚C ) decreased after installation of bag house but there is no significant change in smoke and CO is observed. CO levels tend to be higher in older boilers compared to newer ones. Highest removal efficiency of SOx is observed which is 74.16% followed by NO 62.79% and $NO_x$ 60.59%.

**Keywords:** Bag house Filter, Boiler emissions, Heavy Fuel Oil, Jet Pulsing Dust Collector

## 1. INTRODUCTION

Numerous industrial activities result in the discharge of air pollutants, and among these, particulate matter stands out as a significant concern due to its detrimental impact on both the environment and human well-being. Effectively curtailing the release of dust into the atmosphere is of paramount importance. In recent decades, the drive for enhanced methods of dust reduction has been spurred by increasingly stringent regulations, as highlighted by Ginestet et al. (2022). Undoubtedly, the significance of industrial development in driving economic growth cannot be overstated. However, industries also stand as significant contributors to global air pollution (Liu et al., 2019). These emissions from industrial activities encompass a range of air pollutants, including particulate matter, carbon oxides, nitrogen oxides, volatile organic compounds (VOCs), and persistent organic pollutants. These pollutants pose substantial threats to both human health and the environment (Geng et al., 2019).

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In recent times, there has been notable concern surrounding fine particulate matter primarily because of its substantial health hazards ( Manisalidis et al., 2020). An efficient strategy for eliminating fine particles from the air involves the utilization of dust collection technology (Zheng et al., 2018), where bag filters have gained extensive adoption for industrial air purification due to their effectiveness in capturing a broad spectrum of particle sizes ( Burnett, et al., 2018).

Electrostatic precipitators (ESPs) and bag filter systems are extensively employed for the elimination of solid particulates from manufacturing process gases. ESPs are recognized to exhibit collection efficiencies ranging from 99.5% to 99.9% for larger particles with diameters spanning between 2.5 and 10 micrometers (μm), designated as PM10. However, ESPs tend to exhibit diminished collection efficiency for finer particles (Cuiping et al., 2013). In contrast, bag filters, constructed from fabric materials, not only exhibit exceptional separation efficiency (exceeding 99.99%) but also possess commendable capability for collecting fine. This technology finds widespread application in various industrial settings to capture solid particulate matter present in process gas streams (Cuiping et al., 2013). For instance, fabric filters have emerged as a viable alternative for dust collection, effectively capturing fly ash from flue gas (Ortiz et al., 2007).

Bag filters have demonstrated their utility in diverse scenarios, such as the removal of fly ash ( Cuiping et al., 2013), polychlorinated dibenzo-p-dioxins (dioxins) (Wang et al., 2009), and carbon particles suspended in flue gas (Fino et al., 2009). Throughout the filtration procedure, particles progressively accumulate on the filter bag's surface, forming a layer of powdery cake. This accumulation results in an escalation of the pressure drop across the filtration process (Thomas et al., 2001). To circumvent a decline in the flow of dusty gas and a subsequent surge in energy consumption, periodic regeneration of the filter becomes necessary (Simon et al., 2010). Consequently, the swift buildup of a compact filter cake necessitates more frequent cleaning cycles, leading to increased instances of process downtime. Furthermore, frequent cleaning also contributes to the reduced longevity of the filter bag (Park et al., 2003). Hence, a primary objective in air filtration using bag filters remains the reduction of resistance imposed by the cake layer. Various factors influence the resistance exhibited by filter cakes, encompassing operational conditions like filtration velocity and dust concentration (Hsiao et al., 2018), as well as the characteristics of the dust, including particle size (Hennemann et al., 2021) and sphericity (Deshpande et al., 2020). The resistance attributed to the filter cake is primarily governed by factors such as the mass loading and cake porosity (Chen et al., 2009). Enhancing particle deposition efficiency (YFan et al., 2013) or fostering the formation of a less compact filter cake can aid in mitigating cake resistance (Guangyu Zhou, 2023).

The functioning principles of a pulse-jet cleaning system have been explored by various researchers (Morris, 1984; Sievert and Löffler, 1987). They've identified that certain parameters and equipment factors, such as compressed air pressure, injection duration, injection pipe geometry (hole type, hole diameter, nozzle), distance between injection pipe and filtering elements, and the use of a venturi, influence the cleaning process of filter elements. Achieving optimal performance for the pulse-jet baghouse necessitates ensuring uniform detachment of dust cake from filtering elements and

uniform cleaning across all filter elements. The significance of hole diameter in injection pipes has been underscored by various studies (Simon et al., 2007; Andersen et al., 2016; Thumbe et al., 2017; Li et al., 2019). Empirical and computational investigations have been conducted to assess airflow within injection pipes and ascertain pressure, mass flow rate, and the angle of inclination of the air jet exiting the holes in injection pipes (Thumbe et al., 2017).

Thumbe et al. (2017) suggest that achieving uniform cleaning of all filter bags within a pulse-jet bag house requires equal mass flows through the holes in the injection pipe. Their findings reveal that at the outlet of holes with identical diameters, the mass flow rates exhibit non-uniformity, with the exit angle of air jets not aligning coaxially with the holes' axis. The mass flow rate and the angle of the air jet's inclination are contingent upon the hole's position. Holes situated closer to the tank exhibit lower mass flows and larger inclination angles. The variations in certain flow characteristics, such as mass flow rate and jet angle at the hole's outlet, likely contribute to disparities in the cleaning efficiency of filter bags positioned beneath nozzles of the same injection pipe.

Hemerka and Doubek (2002) formulated a guideline for achieving uniform compressed air distribution within the injection pipe, grounded on a constant flow momentum from the nozzles. They proposed a methodology to design hole diameters in the injection pipe, utilizing the inner diameter of the injection pipe, the number of cylindrical holes, and the nominal hole diameter.

Li et al. (2019) conducted an investigation on an experimental pulse-jet baghouse that featured five parallel pleated cartridge filters. To characterize the influence of pulse-jet cleaning, the authors introduced the concept of "composite pressure," which factors in the peak static pressure distribution within the cartridges. The authors assert that an ideal scenario would involve equal composite pressure values across all cartridges belonging to the same injection pipe. In their study, the composite pressure demonstrates an ascending trend along the injection pipe, with the fifth cartridge exhibiting a value 1.73 times that of the first cartridge. He proposed a modification to the injection pipe's geometry, wherein the orifice diameter decreases from the inlet to the pipe's end. With this revised configuration, the composite pressure profile becomes notably more uniform, with the fifth cartridge's value being only 1.09 times that of the first cartridge. Consequently, this altered geometry has several effects on cartridge behavior: a reduction in residual pressure drop post-cleaning, an extension of the cleaning cycle duration, and a decrease in average dust emissions. This is despite the fact that the peak emission immediately after cleaning experiences an increase. The aim of this study is to monitor the flue gas data of boiler emissions and efficiency of bag house filter in controlling boiler air emissions.

## 2. METHODOLOGY

The automatic Jet Pulsing Dust Collector type bag house is studied which is installed on boiler of capacity 06 ton at shoes manufacturing industry, Batapur, Lahore. Process flow diagram of shoes manufacturing industry is shown in figure 1. The said industry used natural gas and furnace oil as a fuel in boiler. 06 to 07 months natural gas is used as a fuel or on its availability whereas furnace oil is used in winter. The bag filter contained 30 bags made of imported glass fiber. There are 05 lines and in one line

there are 6 filters each. The schematic diagram of pulse jet bag filter to control air emissions is shown in figure 2 and 3.The equipment consists of bag filters, nozzles, fan and tube sheets. Design and physical properties of bag filter material are depicted in Table 1.

The most recent cleaning technique, high pressure cleaning with pulse jets, is used. A jet of compressed air is delivered into the top entrance of the filter to clean it. The air is supplied via a blowpipe that feeds into venturies (to increase velocity) above each filter. The shockwave created by the air blow forces the cloth to bend down the length of the filter. The dust cake splits as the filter bends, and dust falls into the hopper below. The cleaning frequency and cycle for the pulse jet system are crucial for maximum efficiency and are controlled by an adjustable timer. There are no moving parts in pulse jet cleaning, and it cleans on demand.

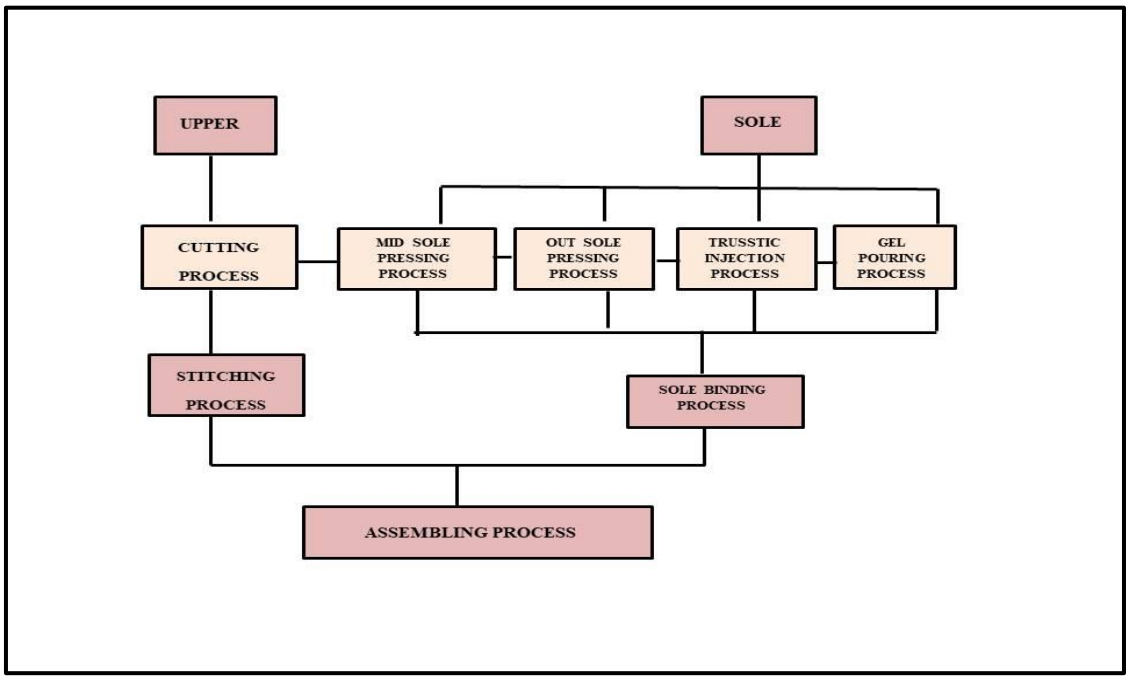



**Figure-1: Process flow diagram of shoes manufacturing industry**

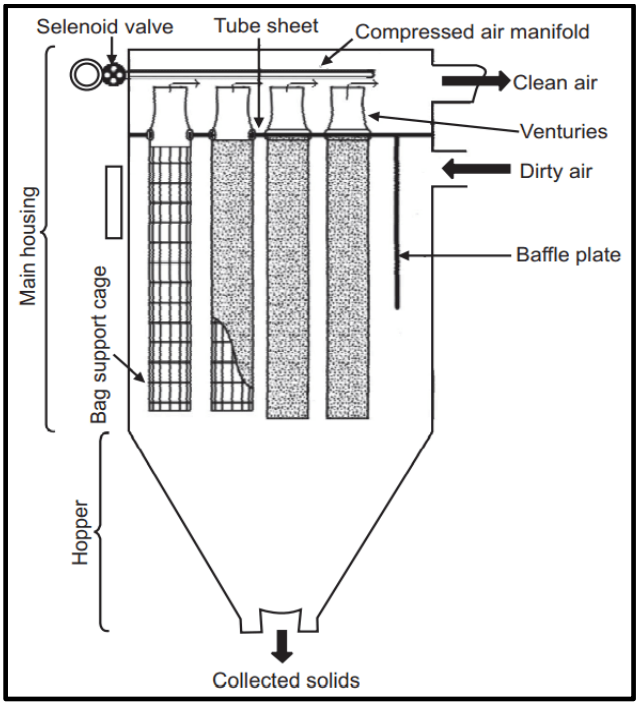



**Figure-2: Schematic diagram of the pulse jet bag house**

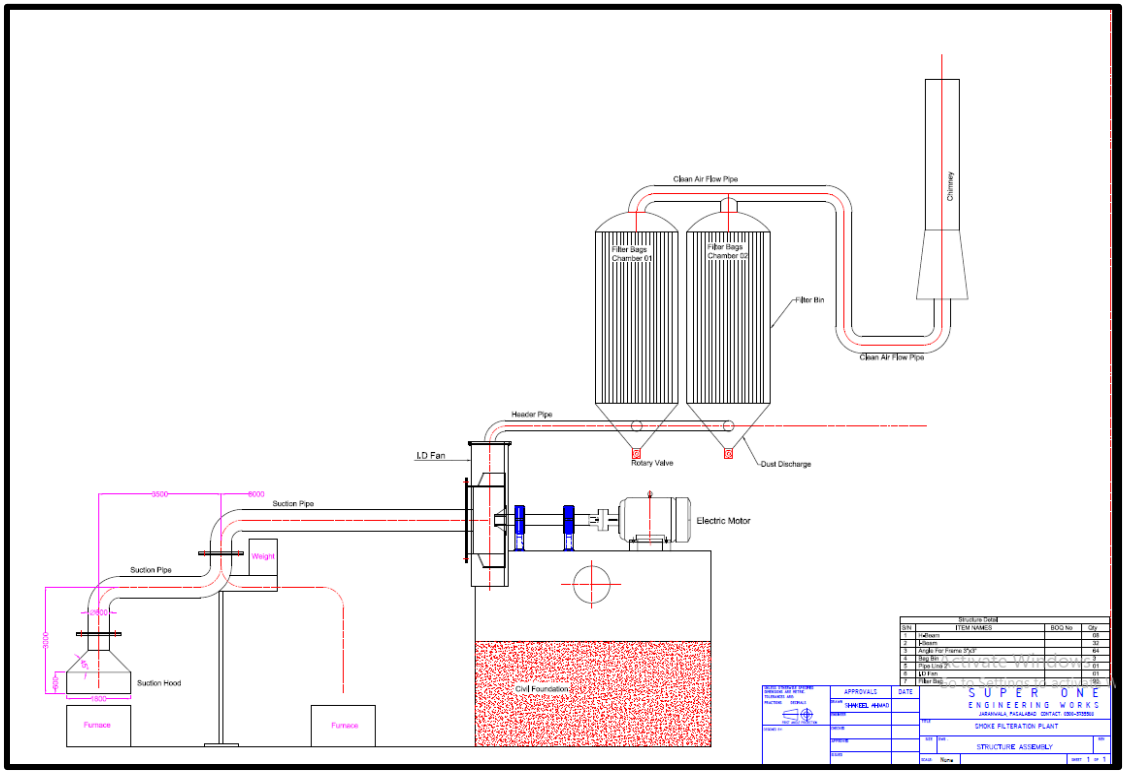



**Figure-3: Layout diagram of the pulse jet baghouse installed at shoes manufacturing industry**

**Table-1: Design of Bag House and Physical Properties of Bag Filter Material**

| **Specifications of installed Bag House(Dust Collector)** | |
|---|---|
| Total Height | 18 feet |
| Plant height without collection system | 12 feet |
| Hopper length | 06 feet |
| Width x Depth | 6x6 feet |
| Electricity consumption | 11KW/hour |
| Height of main duct | 25 feet |
| Bag Filter Material | Glass Fibre |
| Diameter of Bag | 6 inches |
| Bag length | 3.3 meter |
| Height of Bag | 10 feet |
| No. of Bags | 30 |
| **Physical properties of Glass Fibre (Bag Fabric)** | |
| Maximum Continuous Operating Temperature | 290 $^{o}$C |
| Acid Resistance | Good |
| Alkali Resistance | Good |
| Alkali Resistance | Good |
| Flex abrasion resistance | Fair |
| Tensile Strength (kg/cm$^2$ ) | 14,060 |

## 3. RESULTS

Table 2 shows emission data of boilers having capacity of 06 tons with heavy furnace oil used as a fuel, the monitoring parameters are CO, NO, $NO_x$, $SO_x$ and Temperature, $O_2$, $CO_2$, $NO_2$ and Smoke. Values depict that $O_2$ is 3.3%, $CO_2$ is 13.32%, CO is 388.68 mg/Nm$^3$, emission of NO is 192.72 mg/Nm$^3$, $NO_2$ is 30.45 mg/Nm$^3$, $NO_x$ 223.17 mg/Nm$^3$, SOx 2597.22 mg/Nm$^3$, Smoke 20% and Temperature is 196.9 ˚C. The normal velocity at which the gas is passed through the bags is 0.4 to 1 m$^3$/minute. When these values are compared with Punjab Environmental Quality Standards (PEQS), it has been observed that no guideline value set for industrial gaseous emission is available for $O_2$, $CO_2$, NO, $NO_2$ and temperature whereas PEQS limit for CO is 800mg/Nm$^3$, NOx 600 mg/Nm$^3$, 1.62m$^3$, SOx is 1700 mg/Nm$^3$ and smoke is 40% and monitoring values are below these limits.

After installation of bag house filter results show that values of $O_2$ (1.62%), $CO_2$ (6.48%), NO (121 mg/Nm$^{3)}$, $NO_2$ (14.21 mg/Nm$^3$), $NO_x$ (135.21 mg/Nm$^3$), $SO_x$ (1926.06 mg/Nm$^3$)and Temperature (135.7 ˚C )decreases but there is no significant change in smoke and CO is observed after installation as shown in Table 3. Percentage removal efficiency of pollutants after installation of bag house filter is calculated in Table 4. It

shows that NO removal efficiency is 62.79%, $NO_x$ 60.59% whereas highest removal efficiency of $SO_x$ is observed which is 74.16%. Removal efficiency of $O_2$, $CO_2$ and $NO_2$ is less than 50%.Figure 5 also shows that maximum peak of CO and Smoke because value of smoke remain same and there is less difference in CO value before and after installation of bag house filter. Comparison between before and after installation of bag house filter is shown in Figure 4(a) and (b) which shows that after installation of bag house filter there is significant reduction in $SO_x$ and $NO_2$ emissions.

**Table-2. Boiler emissions before installation of Bag House Filter**

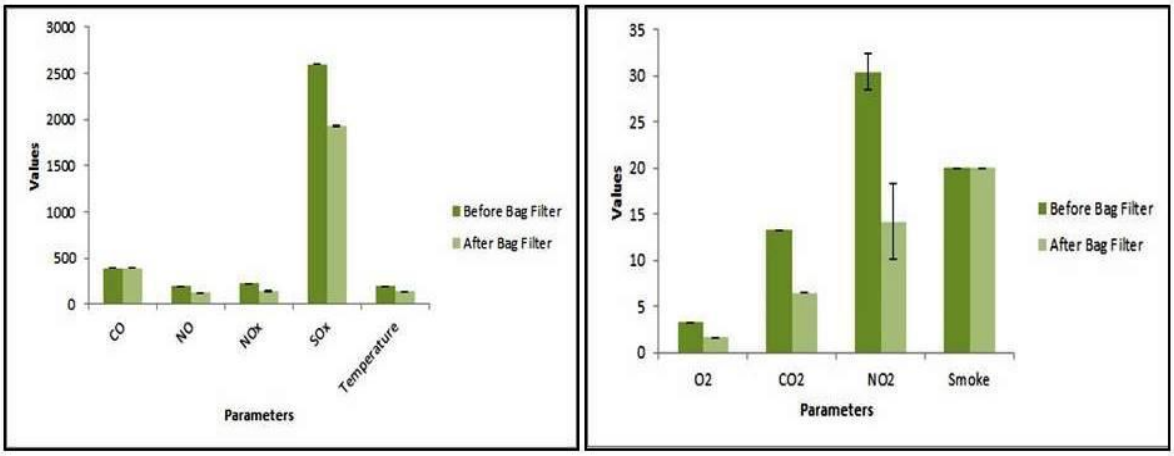
| Sr. No | Parameters | Units | Methods | Reading 1 | Reading 2 | Reading 3 | Average | Standard Deviation |
|---|---|---|---|---|---|---|---|---|
| | $O_2$ | % | Electrochemical | 3.3 | 3.31 | 3.3 | 3.3 | 0.01 |
| | $CO_2$ | % | NDIR Method 10 | 13.32 | 13.32 | 13.31 | 13.32 | 0.01 |
| | CO | $mg/Nm^3$ | OTM-39 | 391.1 | 391.1 | 391.21 | 391.14 | 0.06 |
| | NO | $mg/Nm^3$ | OTM-39 | 192.72 | 191.4 | 194.04 | 192.72 | 1.32 |
| | $NO_2$ | $mg/Nm^3$ | OTM-39 | 30.45 | 32.48 | 28.42 | 30.45 | 2.03 |
| | NOx | $mg/Nm^3$ | OTM-39 | 223.17 | 223.88 | 222.46 | 223.17 | 0.71 |
| | SOx | $mg/Nm^3$ | USEPA Method 8 | 2597.22 | 2600.04 | 2594.40 | 2597.22 | 2.82 |
| | Smoke | % | Ringelmann Scale | 20 | 20 | 20 | 20 | 0.00 |
| | Temperature | °C | - | 197.6 | 196.2 | 196.8 | 196.9 | 0.70 |

**Table-3. Monitoring of boiler emissions after installation of Bag House Filter**

| Sr. No | Parameters | Units | Methods | Reading 1 | Reading 2 | Reading 3 | Average | Standard Deviation |
|---|---|---|---|---|---|---|---|---|
| | $O_2$ | % | Electrochemical | 1.61 | 1.615 | 1.616 | 1.62 | 0.00 |
| | $CO_2$ | % | NDIR Method 10 | 6.45 | 6.49 | 6.5 | 6.48 | 0.03 |
| | CO | $mg/Nm^3$ | OTM-39 | 386.22 | 388.68 | 391.14 | 388.68 | 2.46 |
| | NO | $mg/Nm^3$ | OTM-39 | 117.48 | 121.44 | 124.08 | 121 | 3.32 |
| | $NO_2$ | $mg/Nm^3$ | OTM-39 | 10.15 | 14.21 | 18.27 | 14.21 | 4.06 |
| | NOx | $mg/Nm^3$ | OTM-39 | 127.63 | 135.65 | 142.35 | 135.21 | 7.37 |
| | SOx | $mg/Nm^3$ | USEPA Method 8 | 1917.6 | 1928.88 | 1931.7 | 1926.06 | 7.46 |
| | Smoke | % | Ringelmann Scale | 20 | 20 | 20 | 20 | 0.00 |
| | Temperature | °C | - | 135.4 | 135.8 | 135.9 | 135.7 | 0.26 |

**Table-4. Removal Efficiency calculation of Bag House Filter**

| S. No | Parameters | Units | Before Installation | After Installation | %age efficiency |
|---|---|---|---|---|---|
| | $O_2$ | % | 3.3 | 1.62 | 49.09 |
| | $CO_2$ | % | 13.32 | 6.48 | 48.65 |
| | CO | $mg/Nm^3$ | 388.68 | 388.68 | 99.37 |
| | NO | $mg/Nm^3$ | 192.72 | 121 | 62.79 |
| | $NO_2$ | $mg/Nm^3$ | 30.45 | 14.21 | 46.67 |
| | $NO_x$ | $mg/Nm^3$ | 223.17 | 135.21 | 60.59 |
| | $SO_x$ | $mg/Nm^3$ | 2597.22 | 1926.06 | 74.16 |
| | Smoke | % | 20 | 20 | 100.00 |
| | Temperature | °C | 196.9 | 135.7 | 68.92 |




(a) (b)

**Figure-4 (a) Calculated values of CO, NO, $NO_x$, $SO_x$ and Temperature (b) $O_2$, $CO_2$, $NO_2$ and Smoke before and after installation of Bag House Filter**

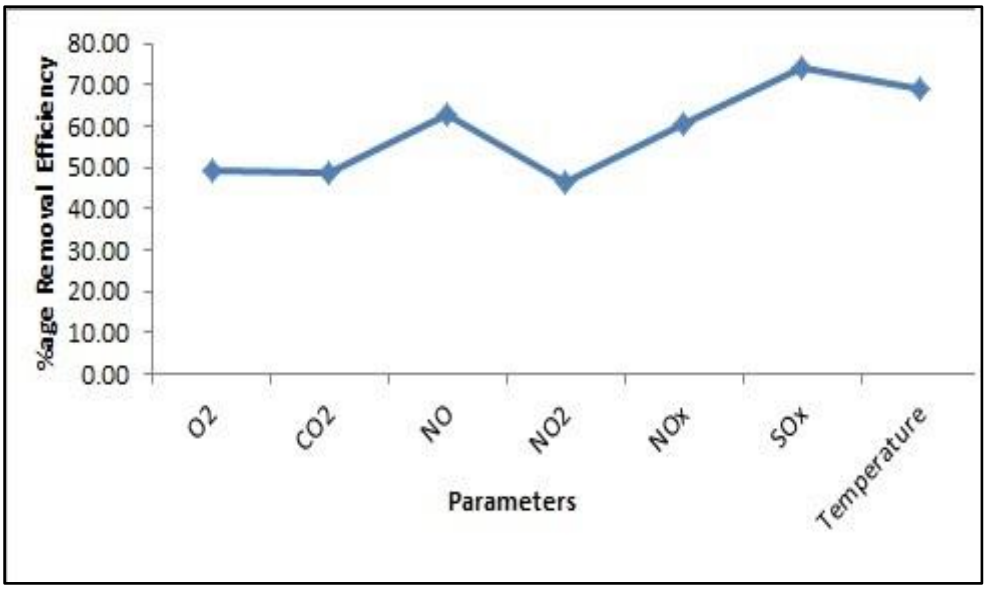



**Figure-5: Percentage Removal Efficiency of parameters $O_2$, $CO_2$,, NO, $NO_2$, $NO_x$ $SO_x$ and Temperature of Bag House Filter**

## 4. DISCUSSION

In a study conducted by S.R.Malik et al. in 2009, it was observed that opting for natural gas as a fuel source could substantially reduce emissions. Natural gas primarily consists of methane, resulting in carbon dioxide and water vapor as the main byproducts during combustion similar to what we exhale when we breathe. In contrast, coal and oil are composed of more intricate molecules with higher carbon ratios, as well as elevated levels of nitrogen and sulfur. Consequently, the combustion of coal and oil leads to heightened emission levels of pollutants, including increased carbon emissions, nitrogen oxides (NOx), and sulfur dioxide ($SO_2$). Furthermore, coal and fuel oil release ash particles into the atmosphere, which are not combustible and contribute to environmental pollution. In contrast, using natural gas as a fuel produce less amount of sulfur dioxide and nitrogen oxide emissions negligible amount of ash or particulate matter and less quantities of carbon dioxide, carbon monoxide and other reactive hydrocarbons.

The most efficient approach for diminishing $CO_2$ levels involves a fuel transition. When utilizing natural gas for combustion, carbon dioxide emissions are notably reduced, with nearly a 30% decrease compared to oil and just under 45% decrease compared to coal (S.R.Malik et al. in 2009).

During the process of combustion, the carbon present in the fuel undergoes a series of reactions to ultimately form carbon dioxide (CO2). However, achieving complete conversion of carbon to CO2 is seldom accomplished in real-world scenarios, often resulting in partial oxidation to an intermediary stage, namely carbon monoxide.

CO levels tend to be higher in older boilers compared to newer ones, mainly due to the relatively recent recognition of CO as a significant issue. Older burner designs were not initially aimed at achieving low CO emissions. In this study, elevated carbon monoxide emissions largely stem from incomplete combustion, which can be attributed to inadequate burner design, suboptimal firing conditions (such as improper air-to-fuel ratio), or even potential furnace leaks. By adhering to proper burner upkeep, conducting regular inspections, appropriate operational procedures, and considering equipment upgrades or the incorporation of oxygen control mechanisms, it is possible

to manage and maintain carbon monoxide emissions at an acceptable threshold. (Energy Solution Centre Organization) .

Numerous experiments were undertaken to assess the impact of baghouse temperature on the removal of NOx. The baghouse temperature was adjusted within the range of 675°F to 850°F (357°C to 454°C) to identify the optimal operating conditions for effective NOx removal. The outcomes of the conducted tests indicated that, in conjunction with the employed catalyst, higher baghouse temperatures led to improved NOx removal it was deduced that achieving the project's objective of 90% NOx removal required a baghouse temperature within the range of 800°F to 850°F (425°C to 454°C). **(**Kudlac, G. A., 1992)

Sangras, R., et al in 2005 discovered that elevating temperatures within fuel-rich environments and prolonging the duration during which fuel-bound nitrogen is present can lead to a decrease in NOx emissions. This process involves the conversion of nitrogen into a molecule resembling CN, which subsequently transforms into $N_2$, all occurring within fuel-rich conditions.

The group of nitrogen oxides, known as NOx, encompasses nitrous oxide ($N_2O$), nitric oxide (NO), nitrogen dioxide ($NO_2$), nitrogen trioxide ($N_2O_3$), and nitrogen pentoxide ($N_2O_5$). Among these, the main focus in relation to air pollution revolves around nitric oxide (NO) and nitrogen dioxide ($NO_2$). Nitric oxide (NO), a colorless gas, acts as a precursor to NO2 and plays an active role in photochemical reactions that lead to the formation of smog. Nitrogen dioxide (NO2), which has a reddish-brown appearance, imparts the color to smog and can contribute to the visibility obstruction of flue gas plumes emitted from stacks.

Boilers are operated with an extra supply of air, known as excess air, to ensure complete combustion and safety. Among the factors impacting the generation of nitrogen oxides (NOx) within a boiler, the level of excess air is noteworthy. Elevated excess air levels can lead to heightened NOx production because the surplus nitrogen and oxygen from the combustion air combine within the flame, forming thermal NOx. The control of excess air intake is achieved through burner design and can be optimized using oxygen trim controls. For most boilers, adopting a strategy of firing with lower excess air is feasible and typically brings about a reduction of 5-10% in overall NOx emissions when natural gas is the chosen fuel (S.R.Malik et al. in 2009)

For industrial boiler operators, the most economically efficient approach to reducing SOx emissions involves the use of low sulfur fuels. Given that the levels of SOx emissions are predominantly tied to the sulfur content within the fuel, opting for fuels with lower sulfur concentrations (such as distillate oil) can lead to diminished SOx output. This reduction can be achieved without the necessity of installing and upkeeping costly equipment. The burning of sulfur-containing fuels, mainly oils and coals, produces pollutants in the forms of sulfur dioxide (SO2) and sulfur trioxide (SO3), collectively known as sulfur oxides (SOx). The quantity of SOx released is directly influenced by the sulfur content in the fuel. The emission levels of SOx are unrelated to the size of the boiler or the design of the burner. Typically, around 95% of the fuel's sulfur content is emitted as SO2, with 1-5% as SO3, and 1-3% as sulfate particulate. It's important to note that sulfate particulate is not considered within the overall assessment of total SOx emissions.

In contrast to NOx, SOx, and CO2, which exhibit reactivity and acidity, carbon monoxide is inert in nature. It possesses minimal dipole and quadrupole moments.

Standard adsorbents like activated charcoal, zeolites, and earth materials fail to comprehensively adsorb carbon monoxide due to its rapid desorption rate. When coexisting with other constituents of flue gas, the adsorption of carbon monoxide on these conventional adsorbents is insignificant. (Puranik and Puranik, 2019).

## 5. CONCLUSION

Air pollution is exerting detrimental effects on both human health and the environment. The emissions data obtained from boilers at shoes manufacturing industry underscores that notable amount of air emissions released when heavy furnace oil is used in boilers. The primary focus regarding air pollution revolves around primary pollutants i.e $SO_X$, $NO_X$, $CO_2$ and CO which pose risks not only individually but also contribute to the development of hazardous secondary pollutants such as ozone and acid rain. The simplest approach to mitigate pollution involves adopting eco-friendly fuels like natural gas and installation of air pollution control devices like bag house. The study shows that bag house plays an important role in highest removal efficiency of SOx i.e 74.16% followed by NO 62.79% and $NO_x$ 60.59%.

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## SEMINAR FOR "BRIDGE INSPECTION AND DIAGNOSIS: HELD ON SATURDAY 03RD JUNE 2023 AT MASHHADI HALL PAKISTAN ENGINEERING CONGRESS HQ

**By**

**Amir Yaqoob**

A seminar was held on 3rd June 2023 (Saturday) in Pakistan Engineering Congress regarding "Bridge Inspection & Diagnosis." The speakers from academia, bridge designers and Japanese expert from Pacific Consultants Pvt. Ltd. hired by Japan International Cooperation Agency (JICA) were invited. The topics of papers presented in seminar were given as under.

Condition Assessment of Bridge (History, Overview and Case Study) by Dr. Azhar Saleem

To index the Bridge Performance by the Vehicle Induced Vibration by Dr. Tauqir Ahmed

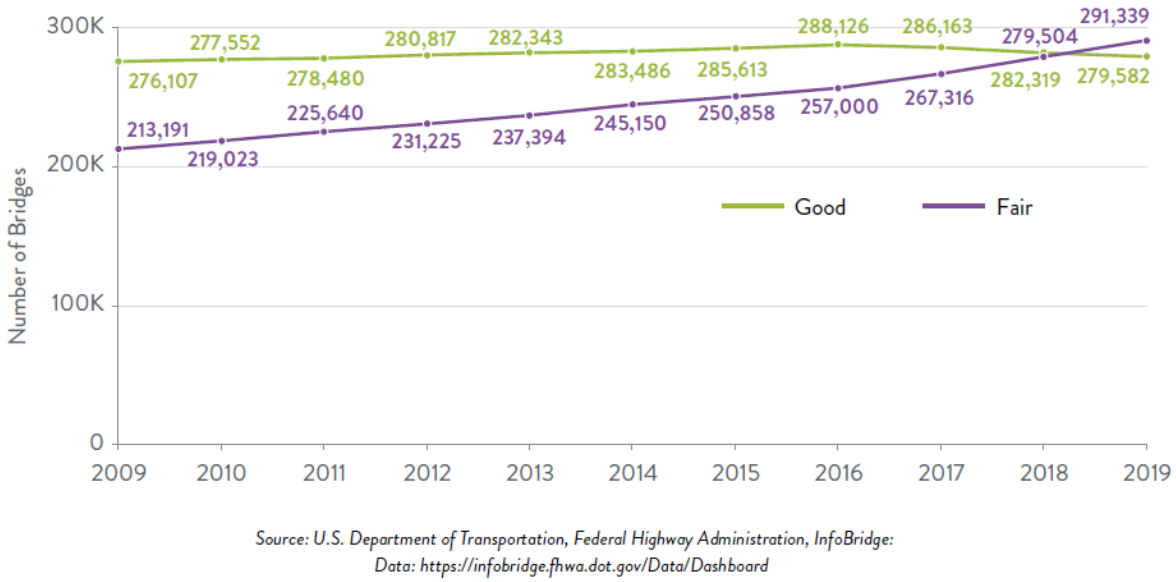
Common Defects Found in Various Bridges and their Rectification Techniques by Engr. Hafiz Shoaib.

Detailed Inspection of Bridges and Rehabilitation by Engr. M. Afzal

Corrosion Damage in Steel Girder Bridge and its Evaluation by Dr. Nauman Khurram

Introduction to Master Bridge Damage Catalogue by Eiichi Tsuji MUTO

**The first paper** was presented by Dr. Azhar Saleem, Associate Professor, Civil Engineering Department of UET Lahore. In the introduction, the history of bridge inspection in USA and formulation of National Bridge Inspection Standards (NBIS), 1971 were discussed. The USA had started bridge condition evaluation and rating system in 1967, when Silver Bridge on Ohio River failed and collapsed in West Virginia resulting in a loss of 46 lives. After this incident, the NBIS were launched as first nationally coordinated bridge inspection program which were updated over the years and latest version was issued in 2022. These standards help the government / authorities in Informed budgetary decisions as part of Asset Management Program. As per these standards each State should maintain a bridge inspection organization and after every two years, bridges are inspected, and National Bridge Inventory (NBI) is updated. In this regard, Specifications for the National Bridge Inventory and Bridge Inspector's Reference Manual (BIRM) were formulated and shared with each State. As a result, it was determined that there are more than 617,000 highway bridges across the United States, 42% are at least 50 years old, 7.5% are structurally deficient, meaning they are in "poor" condition and structurally deficient bridges specifically are nearly 69 years old on average (Infrastructure Report Card, 2021). As per the Federal Highway Administration (FHWA) definition of structurally deficient bridges with one of the key structural elements — the deck, superstructure, substructure, or culverts — are rated in "poor" or worse condition.




*Source: U.S. Department of Transportation, Federal Highway Administration, InfoBridge: Data: https://infobridge.fhwa.dot.gov/Data/Dashboard*

Figure-1: Bridge Condition by Year in USA

In USA, federal government mandates national bridge inspections for all bridges on a periodic basis. Inspection interval can range from 12 to 48 months and is based on the bridge condition, type of bridge, traffic, location, and age of the structure. If the bridge inspector finds any deficiency in the structural capacity, that bridge could be posted for weight, or speed restrictions, temporarily repaired; and/ or closed (Infrastructure Report Card, 2021).



Figure-2:I-35W bridge, Minneapolis, 2007

After the collapse of I-35W Bridge in August 2007, a joint ASCE/SEI-AASHTO ad-hoc group was formed to review the in-place bridge maintenance and inspection policies. The findings of inspection group included that (1) risk-based approach should be adopted to determine the inspection interval for bridges, instead of a pre-defined 2-year cycle. (2) Good condition bridge would be inspected after a period longer than 2 years. In Europe, longer inspection periods are normal, as much as 6 years in some cases (ASCE/SEI-AASHTO Ad-Hoc Group, 2009).

The limitation in bridge management system in USA is that National Bridge Inventory no longer tracks functionally obsolete bridges, there are still over 94,000 bridges nationwide with inadequate vertical or horizontal clearances or inadequate approach roadway geometry. Such bridges do not serve current traffic demand or meet current standards, and many of these bridges act as bottlenecks, increasing congestion and crash vulnerability due to inadequate widths, lanes, or shoulders, substandard vertical clearance, or insufficient lanes for traffic demand (Infrastructure Report Card, 2021).

Now, America's emphasis has slowly evolved from building new bridges to maintaining existing ones. New technologies, materials, evaluation techniques, and construction methods have advanced in recent years to meet this challenge. AASHTO now requires new bridges to be designed with a 75-year service life, compared to the customary 50 years, meaning bridges are now being built to last longer. Bridge engineers are now using materials such as ultra-high-performance concrete, corrosion-resistant reinforcement, high performance steel, composites, and improved coatings. All this increases resilience and adds durability, higher strengths, and longer life to bridges. New technologies are being deployed to assess bridge conditions such as infrared thermography, ground-penetrating radar, and remotely operated surveillance devices like flying and submersible drones (Infrastructure Report Card, 2021).

To have real time inspection process, engineers are designing "living bridges" where sensors are being embedded into new and existing structures to provide continuous feedback on structural conditions. Prefabricated bridge elements and Accelerated Bridge Construction are being used with more frequency to reduce the amount of time traffic needs to be disrupted while a bridge is repaired or replaced. All of these innovations, technologies, and evaluation methods are effectively allowing engineers to identify problems earlier, increase the lifespan of the bridges, stretch limited resources, and prioritize public safety (Infrastructure Report Card, 2021).

Contrary to USA, Reactive Approach of agencies in Pakistan is more common with no mandated requirement for periodic inspection and national bridge inspection standard/manual. As an initiative, a study was carried out by speaker with his MSc student as research project with scope of (1) visual condition rating of two highway bridges in the city of Lahore (2) propose an index which would represent the condition of concrete highway bridges in Pakistan and (3) emphasize on the need to adopt proactive approach for bridge maintenance and to develop a BMS in the country. Fortress Bridge constructed in 1974 and Sherpao Bridge constructed in 1974 were inspected in research project. Methodology covered the preliminary inspection, Development of as-built drawings, Coding of all members, condition rating of all members and development of Bridge Performance Index (BPI). BPI is an index from 0 – 10, designed to indicate the overall condition and performance of the bridges based on structural elements and non- structural elements.

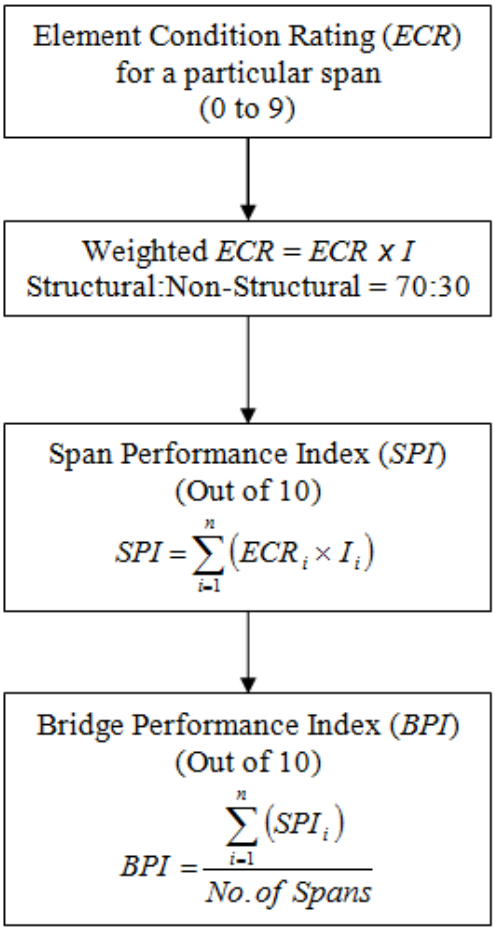



Figure-3: Bridge Performance Index (BPI)

The study concluded that there is a need to prepare bridge inventory and database of BPIs for entire bridge stock of Pakistan, which can be used to develop bridge management system (BMS). Structural elements of both bridges were in good condition however, non-structural elements like expansion joints, bearings, and drainpipe were in poor condition. Given the circumstances in the country, the frequency of Inspection should be decided based on the condition of the bridge and environmental/geographical conditions but not exceeding a fixed cycle of 2 years. This limiting time of 2 years may be changed based on the observation of several inspection cycles/BPI (M. A. Saleem, 2020).

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**The second Paper** was presented how to index the Bridge Performance by Using Traffic Induced Vibrations by Dr, Tauqir Ahmed, Assistant Professor, Civil Engineering Department, FAST NUCES Lahore. The paper emphasized the use of innovative techniques in bridge inspection rather than time consuming and expensive manual / visual inspection techniques. The research project was under progress by the speaker with his one of the MSc students with the objectives to develop a method for the detection of anomalous bridge span for the purpose of detailed structural health monitoring, considering the traffic flow should not be interrupted and the procedure must be efficient in time, resources, and space. The methodology of research includes recording the traffic induced vibrations, processing the data for Frequency Estimation and evaluation for selection of analogous span/bridge. The research work was mainly carried out on Saggian Bridge over River Ravi in Lahore which is a pre-cast I shaped girder dual carriageway bridge with 2 traffic lanes in each direction. Vehicle induced vibrations were recorded using smartphone accelerometer. The natural frequency from these vibration data was calculated as an indicator of structural integrity. Any decrease in natural frequency ultimately indicated decrease in stiffness of the structure due to various reasons.

Traffic induced vibration are affected by the mass and speed, surface condition, number of vehicles present at a time, different suspension system and condition of expansion joints etc. Due to these variables, it is not easy to get a single value of frequency and there will be a specific range of frequencies while processing the data. The frequency range with the most peaks was assumed to have the most valuable information. So, a valid technique was used to get a single value of frequency that will be the natural frequency i.e., Windowed Fourier Transform, Monte Carlo Simulation. Out of 16 spans, only two spans were found to have different spectrum curves which were further proposed for detailed investigations. Limitation of this study was it could only access the super-structure while deficiency in sub-structure are very hard to estimate.

**The third paper** was presented on topic of common defects in bridges and its rectifications by Hafiz Muhmmad Shoaib, Deputy Director, Directorate of Bridges, Communication and Works Department. Common defects in bridges can be broadly categorized into three main types: (1) Initial Defects which occur during construction e.g., Honeycomb, Cold joint etc. (2) Damages- due to the action of external forces e.g., flood, vehicle load, vehicle collision, earth pressure etc. (3) Deteriorations because of aging and cause changes in condition e.g., carbonation, alkali-silica reaction etc.

Some of the common defects in bridges includes siltation, corrosion of steel reinforcement, cracks, spalling, scaling, honeycombing, efflorescence, neoprene bearing pad, deflection / settlement, scouring, crack on brick masonry, failure of column cap, problems in expansion joint, potholes in deck slab, settlement in approach slab etc. To avoid these defects, regular inspection, maintenance, and rehabilitation are vital for ensuring the long-term performance and safety of bridges.

Properly implementing rectification measures enhance bridge functionality and durability. Cleaning and removal of siltation is equally important for maintenance of bridges. Common rectification techniques include short-creting over exposed reinforcement, carbon sheeting over cracked element or crack injection with suitable sealant, protective coating against scaling, replacement of damaged bearing pads, repair / replacement of expansion joints, partial or complete replacement of slabs,

replacement of piers and transoms and reconstruction of severely damaged bridge. It is also important to ensure collaboration between engineers, construction professionals, academic institution and maintenance teams for effective defect rectification and bridge damages preservation.

**The fourth paper** was presented on “Detailed Inspection of Bridges and Rehabilitation Works” by Engr. Muhammad Afzal, Ex-Director, Directorate of Bridges Communication & Works Department. The purpose of bridge inspection includes confirmation of the results of bridge condition inspection, as built drawings and design documents, investigations necessary for evaluation of defects including physical testing and / or structural analysis, and documentation of the observed defects with sufficient information for future design of required major maintenance works. A specially designed mobile inspection gantry is required to carry out detailed inspection of super structure / underside of the bridge. Detailed inspection normally covers preliminary appraisal of concrete strength, study of the nature and variety of structural crack patterns, signs of internal corrosion in reinforcement and post-tensioning steel, indirect evidence of state of grout in pc pre-stressed beams / RCC beams, determination of failure mechanism, identification of critical spans for detailed investigation and acquisition of photographic evidence of distresses.

General recommendations for rehabilitation of super structure includes re-grouting of the prestressing ducts in the primary structural components for improved durability, crack injection and epoxy repair of cracks, re-formation of damaged expansion joints, replacement of deformed bearings by raising the deck with help of jacks and improvement of the asphaltic riding surface. External prestressing of distressed deck and a system of high tensile multistrand post-tensioning encased and protected in PVC ducts be applied. This system can be installed on the existing structure using specially designed brackets.

Bridge rehabilitation after detailed inspection was carried out for bridge over Harrow River on Haripur Taxila Road in District Rawalpindi by the Communication & Works Department in 2014-16. It was a 13-span bridge with span length of 52.5 feet. The bridge was designed with I-shaped 4 girders along with RCC slab in one span. The foundation of bridge was composed of 4 No piles of 30 inches diameter. The bed of Harrow River at structure location was severely scoured due to narrowing of waterway by dumping of stone dust on upstream bank of river by crushers.



Figure-4: Excessive Scouring in Bridge over Harrow River



Figure-5: Bed of Kansi Nullah Degraded by Excessive Scour due to Dumping of Waste Material on the Banks

Additional piles along with pile cap was proposed along with stonework flooring in effective spans. Guide banks were also proposed and constructed at site to guide water in specific waterway.

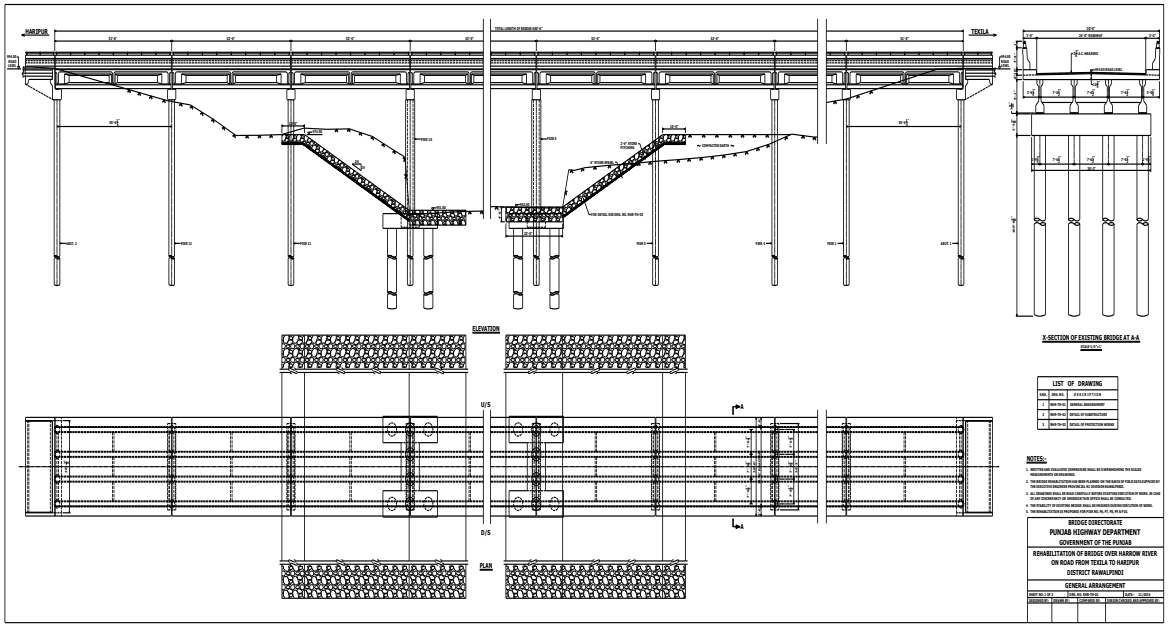



Figure-6: Rehabilitation Work Proposed for Bridge over Harrow River to protect unsafe pile foundations.

**The fifth paper** was presented on corrosion damages in steel girders bridge and their evaluation by Dr. Nauman Khurram, Associate Professor, Department of Civil Engineering, UET Lahore. Majorly, steel bridges in Pakistan are possessed by Pakistan Railway which are mostly constructed in British era. About 48% of total railway bridges (14895 Nos.) are made of steel and currently, 936 Nos. of bridges are abandoned. Many of steel bridges are above 100 years old and affected by wear and tear due to corrosion. Lack of regular maintenance is the main cause of degradation in these steel bridges.

Steel bridges are basically integrated due to fatigue and corrosion. Fatigue depends on traffic volume & intensity, No. of loading cycles while corrosion depends on environment, exposure conditions and preventive measures adopted. Corrosion is complicated to control due to its different patterns and variability in climatic conditions. On the other hands, fatigue can be controlled by restricting the heavy load on steel bridges.

To deal with corroded plate girders, detailed bridge inspection would be the first thing to do. It is also observed that about 50% of corrosion in steel bridges is due to water leakages from joints and cracks. From previous experience, it is observed that general corrosion patterns are highest at end of girders and subsequently thickness reduction in steel cross-section is also highest at end of span Tamakoshi (2005). Flange corrosion reduces the capacity against bending, corrosion in web and stiffeners reduce the bearing capacity and shear capacity of steel girders Real et al. (2007).

Corrosion factors in Pakistan includes high temp in summer ≈ 45 $^0$C, high humidity in rainy season, low maintenance, most of the bridges are on canal and rivers. Therefore, it is recommended that any section with thickness loss of more than 50% should be monitored to avoid any accidental failures, proper maintenance work should be carried out by providing protective coat and critical locations such as flanges on mid-span should be checked more often.

References

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**The last paper** was presented on introduction to master bridge damage catalogue by Eiichi TSUJIMOTO, JICA Expert on bridge maintenance and management. The bridge damage catalogue helps the bridge inspectors in identification of damage severity and overall rating of structure. Federal highway Administration (FHWA) has classified the overall condition of bridge into 9 conditions with score from 1-9. The highest score shows the good condition while the lowest score indicates the severe condition. Poor and severe conditions structures are critical and require some remedial measure to avoid any untoward situation. On the other hands, Japan is using four soundness classification with general raking such as good, fair, poor, and severe.

The overall condition of structure is based on individual raking of each component such as deck, girders, piers etc. It also accounts for non-structural components comprising of expansion joints, railings, surface course, drainage pipes etc. Individual ranking of each component (structure / non-structural) is again classified into four categories (good, fair, poor & severe). The good condition covers no problem in element or some minor problems. Fair condition covers minor deterioration in structural elements, or all primary structural elements are sound but may have minor section loss, cracking, spalling, or scouring. Poor conditions cover the advanced section loss, deterioration, spalling / scouring or serious condition due to affected primary component or localized failure. Server condition covers the critical or imminent failure condition in which bridge must be closely monitored or closed for traffic.

The damage catalogue mainly covered the type of damage, description to its severity level along with photographs. The type of damages mainly included in catalogue are scouring of foundation, delamination / spall / patched area, exposed rebar, efflorescence / rust staining, cracking, abrasion/ wear, distortion, settlement, scour and damage. The elements to be inspected are covered in catalogue which includes prestressed concrete, concrete protective coating, masonry, concrete reinforcing steel protective systems, joints, steel, steel protective coating, timber, wearing surface and bearings.