Artificial Intelligence and Climate Change: Response to Climate-Induced Disasters in Pakistan

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Abstract

Pakistan is grappling with the impacts of climate change, which have intensified the severity of disasters such as flash floods, glacial lake outbursts, droughts, and heat waves. These challenges pose serious threats to the country's livelihoods and economy. One of the several ways to mitigate the impacts of climate change is by utilizing Artificial Intelligence (AI) for data gathering and analysis. This approach can help reduce the increasing frequency of major losses to life and property. However, several systemic challenges hinder progress, including inadequate infrastructure, the unavailability of required data and its proper representation, a lack of skilled manpower, endemic corruption, and a poor governance system. This paper analyzes the UN's efforts to incorporate AI technology into climate mitigation and adaptation strategies, while examining various models employed by countries such as the United States, China, and Japan. The established practices of these countries could serve as a foundation for developing a Pakistan-specific model for flood risk management, disseminating disaster-related information, delivering early weather forecasts, and analyzing potential damage to infrastructure.

Keywords: Climate Change, Artificial Intelligence, Climate-Induced Disasters, Adaptation, United Nations.

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Introduction

Pakistan is one of the most affected countries by climate change, ranking as the "8th most vulnerable country to the climate crisis."[1] This vulnerability manifests in various forms, including flash floods, glacial lake outbursts, droughts, and extreme heat waves, all of which pose numerous challenges to the country.[2] The adverse effects of climate change have intensified in recent years, causing severe damage across multiple sectors in Pakistan. The increasing frequency and severity of climate-related disasters highlight the shortcomings of traditional approaches to managing climate-induced disasters, which have largely proven ineffective. Pakistan, therefore, needs to adopt a proactive approach to developing strategies that enhance its adaptation to climate change.[3]

Emerging technologies present significant opportunities for Pakistan to improve its resilience and adaptation efforts in the face of climate-related challenges. Integration of these technologies, particularly AI, can greatly improve the prediction and management of climate change while strengthening resilience to combat the climate crisis. In this context, ClAI serves as an assistive tool that supports and augments human efforts in adapting to and mitigating the effects of the climate crisis, complementing rather than replacing human intervention.[4] This paper explores how Pakistan can leverage AI in managing climate-induced disasters. AI can play a critical role in disaster preparedness by enhancing early warning systems, enabling the prediction of impending disasters, and facilitating timely responses to mitigate their impact.[5]

1. United Nations Development Programme, "Climate Promise – II," *UNDP.* https://www.undp.org/pakistan/projects/climate-promise-ii.
2. Relief Web, "Melting glaciers, growing lakes and the threat of outburst floods – Pakistan," August 26, 2022. https://reliefweb.int/report/pakistan/melting-glaciers-growing-lakes-and-threat-outburst-floods
3. Zain Ul Abideen Siddiqui, "Pakistan's first-ever climate change plan unveiled," *The Express Tribune,* July 26, 2023. https://tribune.com.pk/story/2427999/pakistans-first-ever-climate-change-plan-unveiled
4. Donald Thompson, "Assistive AI, Not Autonomous AI, Is the Path to Improved Operational Efficiencies," *Forbes*, December 21, 2017. https://www.forbes.com/sites/forbestechcouncil/2017/12/21/assistive-ai-not-autonomous-ai-is-the-path-to-improved-operational-efficiencies/.
5. Harshita Jain and Renu Dhupper. "Ai-Enabled Strategies for Climate Change Adaptation: Protecting Communities, Infrastructure, and Businesses from the Impacts of Climate Change," *Computational Urban Science.*

AI technology can also contribute to effective disaster response by identifying and prioritizing vulnerable communities or infrastructure. Additionally, AI-powered chatbots can assist emergency responders and government agencies by facilitating communication, providing real-time updates, and offering guidance for first aid and humanitarian assistance.[6] The potential application of AI can enable Pakistan to develop more efficient adaptation strategies, which are crucial for reducing the adverse impacts of climate-induced disasters. These advancements are particularly essential for countries like Pakistan, where vulnerability to climate change poses significant challenges that require immediate and innovative solutions.

Adaptation requires significant changes in ecological, social, or economic systems in response to climate stimuli and their effects.[7] Mitigation, on the other hand, involves methods to reduce greenhouse gas emissions, which are the primary drivers of climate change. While Pakistan's climate change policy encompasses both mitigation and adaptation, this paper focuses on strengthening Pakistan's adaptation strategies to address the challenges posed by climate change effectively. Pakistan is not a major contributor to greenhouse gas emissions, yet it remains one of the countries that are severely affected by climate change. The fifth Assessment of the Intergovernmental Panel on Climate Change (IPCC) highlights Pakistan's limited adaptive capacity.[8] According to the IPCC Fifth Assessment Report, Pakistan's agriculture and energy sectors are expected to experience significant impacts from climate change.[9] Given that Pakistan's economy is heavily reliant on these two critical sectors, a comprehensive approach to adaptation is essential. This approach should focus on reducing vulnerability by integrating AI technology to enhance resilience and ensure sustainable development.

https://www.researchgate.net/publication/372458556_AI-enabled_strategies_for_climate_change_adaptation_protecting_communities_infrastructure_and_businesses_from_the_impacts_of_climate_change

6. Charlotte Lancaster, "Can Artificial Intelligence Improve Humanitarian Responses?" *UNOPS*. October 25, 2018. https://www.unops.org/news-and-stories/insights/can-artificial-intelligence-improve-humanitarian-responses

7. UNFCC, "Adaptation and Resilience." https://unfccc.int/topics/adaptation-and-resilience/the-big-picture/introduction#:~:text=Adaptation%20refers%20to%20adjustments%20in,climatic%20stimuli%20and%20their%20effects

8. Qamar Uz Zaman Chaudhry, "Climate change profile of Pakistan," 2017. https://www.adb.org/sites/default/files/publication/357876/climate-change-profile-pakistan.pdf

9. Chaudhry, "Climate change profile of Pakistan."

This paper explores how Pakistan can incorporate AI technology to adapt to climate-induced disasters. The first section of this study examines the problem of climate change and the UN's efforts to address it. The second section analyzes the impacts of climate change on Pakistan. The third section focuses on the role of AI in combating climate change examining the established AI models used by the United States, China, and Japan for climate disaster response. The fourth section explores the potential for integrating AI technology in Pakistan to enhance climate adaptation strategies. The last section of the paper addresses the possible challenges Pakistan may face in adopting AI technology for this purpose.

Global Efforts to Combat Climate Change

The effects of climate change range from shifting weather patterns to the melting of glaciers, which contribute to rising sea levels and, ultimately, an increased frequency of floods. These changes result from long-term shifts in temperatures and weather patterns driven by human activities, particularly the burning of fossil fuels such as coal, oil, and gas.[10] To reduce the burning of fossil fuels, the UN has established a common platform under the United Nations Framework Convention on Climate Change (UNFCCC), enabling countries to negotiate, discuss, and agree on climate-related actions aimed at reducing greenhouse gas emissions. This convention has resulted in several significant agreements, including the Kyoto Protocol, the Paris Agreement, and the Glasgow Climate Pact.[11]

The primary objective of the UNFCCC was to recognize the climate crisis as a global issue and to minimize human interference in the climate system.[12] The UNFCCC organized regular meetings among the ratifying parties, known as the Conference of the Parties (COP).[13] These meetings led to the first successful agreement at COP 3 in Kyoto, resulting in the Kyoto Protocol, the first legally binding climate treaty. However, the Kyoto Protocol and subsequent agreements failed to achieve significant reductions rise in global temperatures. This failure eventually prompted states to prio-

10. United Nations, "What Is Climate Change?" *United Nations*, https://www.un.org/en/climatechange/what-is-climate-change.
11. Lindsay Maizland, "UN Climate Talks," *Council on Foreign Relations,* September 18, 2019. https://www.cfr.org/timeline/un-climate-talks
12. Maizland, "UN Climate Talks."
13. "UN Climate Talks."

-ritize adaptation strategies, culminating in the adoption of the Paris Agreement at COP 21.[14] The new agreement promised funding to poor and more vulnerable countries for developing programs and policies that could facilitate adaptation. The UN's various climate financing projects aim to support developing countries in addressing the issue of climate change. These projects are funded by developed countries due to their greater economic capacity and their significant responsibility for the looming climate catastrophe.[15] Despite promises made by these polluters, many have failed to fulfill their climate financing obligations of US $100 billion annually by 2020, which could have significantly aided developing nations in adapting to the climate crisis.[16]

The transition to clean energy and the development of adaptation strategies can only be achieved if vulnerable countries, like Pakistan, receive the promised financial support from major industrialized nations. At COP-26, Pakistan strongly emphasized that achieving a "total target of 50 percent emissions reductions by 2030 is only possible if US $100 billion is provided to facilitate a clean and just energy transition."[17] This appeal may have influenced the participants of COP-27 to establish funds aimed at compensating poor and vulnerable countries. At the subsequent COP-28, held in Dubai, further commitments were made by the participants to support these efforts.[18] The main highlight of COP-28 was the establishment of the "Loss and Damage and Adaptation Fund," which is crucial for countries like Pakistan to mitigate the negative impacts of looming climate-induced disasters.[19] As vulnerable countries work on developing new policies and strategies, they should also leverage emerging technologies, such as AI, which can offer innovative solutions to address the challenges posed by climate change.

14. United Nations, "The Paris Agreement," https://www.un.org/en/climatechange/paris-agreement.
15. United Nations Climate Change, "Introduction to Climate Finance," https://unfccc.int/topics/introduction-to-climate-finance
16. Fiona Harvey, "Rich Countries Hit $100bn Climate Finance Goal Two Years Late, Data Shows," *The Guardian*, November 16, 2023. https://www.theguardian.com/global-development/2023/nov/16/rich-countries-hit-climate-finance-goal-two-years-late-data.
17. Aron White, "We don't believe in Net-zero at the Moment- Pakistan's top climate official at COP26," *Dawn*, November 4, 2021. https://www.dawn.com/news/1655944.
18. Fiona Harvey, "Cop27 Agrees Historic 'Loss and Damage' Fund for Climate Impact in Developing Countries," *The Guardia*n, November 20, 2022. https://www.theguardian.com/environment/2022/nov/20/cop27-agrees-to-historic-loss-and-damage-fund-to-compensate-developing-countries-for-climate-impacts.
19. Cristen Hemingway Jaynes, "COP28 Agrees to Establish Loss and Damage Fund for Vulnerable

Impact of Climate Change on Pakistan

One of the most significant climate-related challenges Pakistan has faced in recent decades is flooding. The August 2024 report by the National Disaster Management Authority (NDMA) identified an unprecedented monsoon season as the primary cause of heavy rainfall across the country, which led to widespread flooding, substantial damage to infrastructure, and the tragic loss of 196 lives.[20] UN Secretary-General, António Guterres famously described the 2022 floods as "a monsoon on steroids."[21] Unfortunately, the floods continued to wreak havoc in 2023, further compounding the challenges for the nation.

Pakistan is an agrarian country where agriculture serves as the backbone of the economy, providing livelihoods, contributing significantly to the Gross Domestic Product (GDP), and forming a major portion of the country's exports.[22] Reports from the NDMA indicate that climate-induced disasters could have severe repercussions for Pakistan's agriculture sector. Projections suggest that agricultural output could decline by 8-10 percent by 2040 due to rising temperatures and shifting rainfall patterns, which are likely to result in crop failures and reduced yields.[23] Each year, climate change continues to cause significant damage to crops, thereby adversely affecting the livelihoods of millions of people dependent on agriculture. The increasing climate vulnerability, exacerbated by frequent flooding, has become a major source of anxiety for those involved in agriculture, as it creates an uncertain and unpredictable future for their livelihoods.[24]

Countries," *World Economic Forum,* December 1, 2023. https://www.weforum.org/agenda/2023/12/cop28-loss-and-damage-fund-climate-change/.

20. Relief Web, "NDMA Monsoon 2024 Daily Situation Report No. 50 (19 August 2024)," August 20, 2024. https://reliefweb.int/report/pakistan/ndma-monsoon-2024-daily-situation-report-no-50-19-august-2024

21. British Red Cross, "Flooding in Pakistan: the latest news," https://www.redcross.org.uk/stories/disasters-and-emergencies/world/climate-change-and-pakistan-flooding-affecting-millions

22. Anam Azam and Muhammad Shafique, "Agriculture in Pakistan and its Impact on Economy——A Review," *International Journal of Advanced Science and Technology*, 2017. https://article.nadiapub.com/IJAST/vol103/5.pdf

23. Shakeel Ahmad Ramay, "Climate Change Killing Agriculture," *The Express Tribune*, June 6, 2022. https://tribune.com.pk/story/2360219/climate-change-killing-agriculture

24. Maha Akbar, "Over a Year After Pakistan Floods, Survivors Battle Climate Anxiety," *Al Jazeera*, October 24, 2023. https://www.aljazeera.com/gallery/2023/10/24/photos-over-a-year-after-pakistan-floods-survivors-battle-climate-anxiety

For NDMA, the 2023 floods resulted in the displacement of 162,257 people and the submergence of 153,231 acres of land with standing crops.[25] Additionally, the loss of 448 livestock further contributed to the hardships faced by this vulnerable community.[26] The table below provides a detailed summary of the damages to infrastructure, houses, and livestock.

Province / Region	Roads(Kms)	Bridges	House Damage			Livestock
			Partial	Full	Total	
Balochistan	43	7	303	125	**428**	131
Khyber Pakhtunkhwa	0	6	561	212	**773**	139
Punjab	0	0	148	100	**248**	44
Sindh	0	0	634	242	**876**	41
Gilgit Baltistan	1.5	14	105	64	**169**	80
Azad Jammu & Kashmir	0.233	4	56	25	**81**	3
Islamabad Capital Territory	0	0	0	0	**0**	10
Total	**44.733**	**31**	**1807**	**768**	**2575**	**448**

Figure. 1: Cumulative Damages from floods – 1st July to 19th August 2024
Source: NDMA - Monsoon 2024 Daily Situation Report No. 50[27]

Between July 1 and August 19, 2024, floods caused significant damages across various regions of Pakistan, as reported by NDMA. Balochistan faced the highest damage to roads (43 km) and bridges (7), while Khyber Pakhtunkhwa recorded the most affected houses, with 773 either partially or fully damaged. Sindh experienced the highest number of fully damaged houses (242), totaling 876 affected homes. Gilgit-Baltistan saw 14 bridges damaged, the most in any region, along with 169 affected houses. Livestock losses were highest in Balochistan (131), followed by Khyber Pakhtunkhwa (139). Minimal damage was reported in Punjab, Azad Jammu & Kashmir, and Islamabad Capital Territory, with the latter recording no damage to roads, bridges, or houses but a loss of 10 livestock. In total, 44.733 km of roads, 31 bridges, 2,575 houses, and 448 livestock were impacted across the

25. Relief Web, "Pakistan: Floods - Jun 2023," April 8, 2024. https://reliefweb.int/disaster/fl-2023-000119-pak.
26. Relief Web, "NDMA Monsoon 2024 Daily Situation Report No. 50 (19 August 2024)," August 20, 2024. https://reliefweb.int/report/pakistan/ndma-monsoon-2024-daily-situation-report-no-50-19-august-2024
27. NDMA Monsoon 2024 Daily Situation Report No. 50 (19 August 2024)."

country. To mitigate the devastating effects of climate change, Pakistan must focus on enhancing community preparedness through the adoption of advanced technologies that enable better forecasting and the development of effective adaptation strategies. These measures can help reduce the impacts of such disasters and safeguard the livelihoods of vulnerable populations.

The Role of Artificial Intelligence in Combating Climate Change

Emerging technologies have opened new opportunities to simplify life and advance solutions for modern challenges. Around the world, various countries are leveraging these technologies to mitigate and adapt to the climate crisis. Technologies such as AI, the Internet of Things (IoT), 5G, digital twins, robotics, Space 2.0 technologies, and Big Data are being applied to address the pressing challenges posed by climate change.[28] Among these, AI stands out as the most notable and impactful technology, as it is being extensively used to mitigate the adverse effects of climate change. AI is helping to develop better adaptation strategies by improving climate modeling, optimizing resource management, and enabling precision agriculture, making it a vital tool in combating the global climate crisis.

AI is still in its developmental phase, with ongoing advancements in various domains, particularly in climate adaptation. However, being at a nascent stage, many developing countries lack access to advanced mechanisms of assistive AI, while developed countries have made significant progress in this field. For developing countries, incorporating assistive AI is particularly crucial due to the more pronounced and visible impacts of climate change they face. These countries often have fewer resources and less adaptable strategies to cope with climate-related challenges. Recognizing this disparity, the UN is now actively working on initiatives to incorporate AI technology into climate action efforts in developing countries. The UN, under the UNFCCC, has taken proactive steps to incorporate AI technology in efforts to mitigate climate change.[29]

28. ASEAN Climate Change and Energy Project (ACCEPT), "Yunnan, "Emerging Technologies to Respond to Climate Change," September 15, 2021. https://accept.aseanenergy.org/emerging-technologies-to-respond-to-climate-change/.
29. Unfccc.int, "Technology Mechanism Initiative on Artificial Intelligence for Climate Action," https://unfccc.int/ttclear/artificial_intelligence

At the 2010 COP-16, the Technology Mechanism of the UNFCCC was established to accelerate the development and deployment of climate-related technologies. This mechanism comprises two complementary bodies: the Technology Executive Committee (TEC) and the Climate Technology Centre and Network (CTCN).[30] The TEC focuses on policy analysis and provides recommendations to countries, while the CTCN supports countries in implementing climate technology projects. Recognizing the transformative potential of AI, a focused initiative on its integration into climate solutions was introduced at COP-28. This marked a pivotal moment, as the Technology Mechanism began emphasizing the use of AI to address climate change-related challenges, paving the way for innovative strategies to curb its impacts and enhance global climate resilience.

At COP-28, the transformative potential of AI in addressing climate change was a key focus. The Technology Executive Committee (TEC), in collaboration with the non-profit open-source AI community Enterprise Neurosystem, launched the "AI Innovation Grand Challenge."[31] This initiative convened global leaders to discuss how AI could be harnessed to drive transformative climate action, particularly in developing countries. In 2023, the UN further reinforced its commitment by introducing the "AI4ClimateAction" initiative. This project explores the application of AI in climate change mitigation and adaptation, with a strong emphasis on developing countries. The aim is to enhance climate resilience and facilitate low-emission development pathways.[32] The AI4ClimateAction initiative specifically focuses on providing AI-driven solutions for climate adaptation in critical sectors such as agriculture and renewable energy.

Developed countries including, the US, Japan, China, and many other countries are already using AI technology to mitigate climate crisis. These countries can also help developing countries like Pakistan in the field of AI technology so that they can adapt to the changes by climate change and learn from the technologically advanced countries to incorporate AI in their climate security policies.

30. "Technology Mechanism Initiative on Artificial Intelligence for Climate Action."
31. Ians, "Innovation Challenge to Develop AI-powered Solutions for Climate Action," *The Statesman*, December 10, 2023. https://www.thestatesman.com/world/innovation-challenge-to-develop-ai-powered-solutions-for-climate-action-1503248453.html.
32. "Innovation Challenge to Develop AI-powered Solutions for Climate Action."

Lessons from the United States

The US is actively employing AI technology to address climate change. A notable example is the collaboration between International Business Machines Corporation (IBM) and NASA to develop an AI-based model, watsonx.ai. This advanced tool is designed to process satellite data and convert it into high-resolution flood maps.[33] Through flood mapping, the watsonx.ai model aids authorities in protecting lives and property by identifying high-risk areas, enabling targeted interventions, and steering future development toward safer regions. This demonstrates how major US industries are actively working to adapt to the challenges posed by climate change. In addition to flood mapping, the US has developed AI models specifically aimed at addressing climate change-induced disasters. One such model, referred to as "Coastal AI," uses artificial intelligence to simulate the effects of sea-level rise on coastal infrastructure across the US.[34] The Coastal AI model employs advanced AI algorithms to predict how various types of infrastructure, including roads, bridges, and buildings, will be impacted by rising sea levels. By analyzing data on sea-level rise, land use, and infrastructure vulnerability, the model provides detailed projections of potential damage and risk areas.

Lessons from China

China has also prioritized AI technology in its efforts to combat climate change. As the world's largest greenhouse gas emitter, China made a significant pledge at COP-26 to achieve net-zero emissions by 2060. To support this ambitious goal, China is leveraging AI technology alongside its broader strategic initiatives. Under its "China 2025 Strategy," the country aims to position itself as a global leader in AI technology.[35]

33. Sriram Raghavan and Christina Shim, "Earth's Climate Is Changing. IBM's New Geospatial Foundation Model Could Help Track and Adapt to a New Landscape," *IBM Research Blog*, July 5, 2023. https://research.ibm.com/blog/geospatial-models-nasa-ai.

34. Harshita Jain and Renu Dhupper. "Ai-Enabled Strategies for Climate Change Adaptation: Protecting Communities, Infrastructure, and Businesses from the Impacts of Climate Change," *Computational Urban Science.* https://www.researchgate.net/publication/372458556_AI-enabled_strategies_for_climate_change_adaptation_protecting_communities_infrastructure_and_businesses_from_the_impacts_of_climate_change

35. China AI Strategy, "A New Generation Artificial Intelligence Development Plan (2017)," https://datagovhub.elliott.gwu.edu/chinaaistrategy/#:~:text=Step2%3A%20By%202025%2C%20China%20should,AI%20security%20assessments%20in%20place.

A key component of this strategy is the development of a "green technological innovation system," which integrates AI to enhance environmental protection, reduce emissions, and support sustainable development."[36] China's plan to combat environmental hazards through technology involves the strategic deployment of advanced tools like AI to address ecological challenges. As part of this effort, the Chinese government has introduced guidelines encouraging industries to collaborate with major tech companies to work toward carbon reduction and environmental sustainability. One notable initiative comes from the Chinese tech giant Alibaba, which launched the "Ali Cloud Environmental Protection" program. This initiative leverages Alibaba's cloud computing and AI capabilities to monitor environmental conditions, optimize resource usage, and reduce carbon footprints.[37] The aim is to achieve energy efficiency and carbon neutrality by leveraging AI technology. Beyond energy and carbon management, China is also utilizing AI technology in weather forecasting systems.

Chinese scientists have developed an advanced AI model known as FuXi-Subseasonal, designed to improve the accuracy and duration of extreme weather predictions. This model utilizes sophisticated algorithms and large-scale meteorological data to deliver higher precision and longer-term forecasts for extreme weather events.[38] This model has been instrumental in providing early predictions of weather disasters, allowing for timely preparation and response. When deployed in Yunnan Province, China, which experienced flash floods, the model demonstrated its capability to forecast such events well in advance.[39] However, with the use of AI, assessing the flash flood risk in Yunnan Province based on historical records and generating early warnings became easier. Similarly, Fengwu Meteorological, another AI model used in China's weather forecasting system, has been employed to predict and generate early warnings for incoming typhoons such as Talim, Doksuri, and Khanun.[40]

36. "A New Generation Artificial Intelligence Development Plan (2017)."
37. "Alibaba to Provide Access to Powerful Environmental Monitoring AI," n.d., https://news.cgtn.com/news/346b6a4d33557a6333566d54/index.html
38. Zhao Yusha, "China's AI Weather Forecasting Model Front-runner Worldwide," *Global Time*s, https://www.globaltimes.cn/page/202401/1305205.shtml#:~:text=The%20model%2C%20%22FuXi%2DSubseasonal,longer%20forecasting%20period%20than%20existing.
39. Ming Ma and others, "Flash Flood Risk Analysis Based on Machine Learning Techniques in the Yunnan Province, China," January 17, 2019: 170, https://doi.org/10.3390/rs11020170
40. Yusha, "China's AI Weather Forecasting Model Front-runner Worldwide."

Lesson from Japan

In addition to China, Japan has also recognized the potential of early warning systems powered by AI technology. Japan has developed a highly coordinated AI-operated early warning system that integrates advanced technology, institutional frameworks, and community engagement across various levels and scales. Recently, Japan deployed the AI model Fugaku, one of the world's fastest supercomputers, to predict tsunamis in coastal areas before they reach those regions.[41]

This approach enables Japan to predict tsunamis and facilitate early evacuations from affected regions, minimizing potential loss of life and property. Additionally, a Japan-based meteorological service, Weathernews Inc., is actively working to enhance disaster preparedness by providing disaster-related information. The company collaborates with a popular messaging app to deliver real-time updates to customers, ensuring they remain informed and connected during emergencies. Furthermore, Japan has implemented an AI chatbot as part of a program supported by UNESCO.[42] This chatbot is designed to disseminate disaster-related information, answer questions, and assist communities in preparing for and responding to natural disasters.

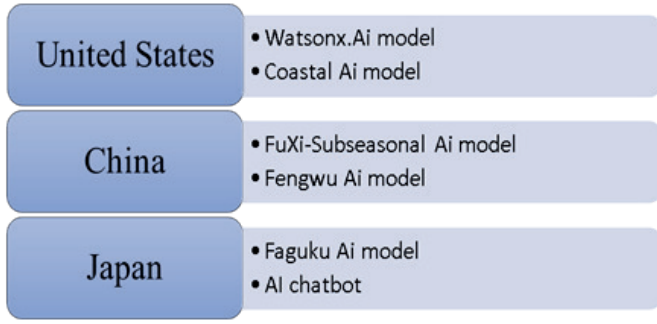

Figure 2: AI Models adopted by different countries

41. Springwise, "World's Fastest Supercomputer Used to Model Tsunamis," February 24, 2021, https://springwise.com/innovation/computing-tech/supercomputer-ai-tsunami-prediction/#:~:text=A%20Japanese%20supercomputer%20is%20being,that%20could%20predict%20tsunami%20flooding

42. Fatima Faisal. "Artificial Intelligence for Flood Prediction and Management: Lessons for Pakistan," *Institute of Strategic Studies Islamabad*, November 2, 2022. https://issi.org.pk/issue-brief-on-artificial-intelligence-for-flood-prediction-and-management-lessons-for-pakistan/.

Countries around the world are increasingly integrating AI technology into their climate adaptation strategies. From predicting extreme weather events to offering tools for building climate resilience, AI is providing an extensive range of innovative solutions. AI-powered models such as Google's Hydronet and Google Street View are being widely adopted globally for climate adaptation efforts.[43] Google Street View is frequently used to track disaster recovery, enabling authorities to assess damage and prioritize recovery efforts efficiently. Similarly, Google Hydronet is being utilized in countries like Bangladesh and India to identify flood-prone areas and predict the severity of flooding, helping these nations implement targeted mitigation strategies. Given Pakistan's heightened vulnerability to climate change, the country should incorporate AI technology into its climate adaptation framework.

Way forward for Pakistan

Pakistan is grappling with escalating challenges due to climate change, including water scarcity, extreme weather conditions, and poor agricultural conditions that contribute to food shortages. To address these pressing issues, Pakistan can leverage the potential of AI technology to develop effective solutions for climate-induced disasters. However, building AI-based climate adaptation strategies requires rapid resource mobilization, for which Pakistan can consider two key approaches. The first approach involves engaging with international platforms like the UN, which have already initiated programs to incorporate AI technology in addressing climate change.

Pakistan can collaborate with the UN to gain access to resources and expertise essential for accelerating the use of AI technology in climate adaptation. The UN, through initiatives like the Technology Mechanism under the UNFCCC, focuses on providing funding and support to developing countries for climate adaptation efforts. Pakistan can leverage these funds to enhance its capabilities in AI-driven solutions for addressing climate crises. The allocated funds can be strategically invested in strengthening and mobilizing the existing institutions working on AI development, such as research centers, academic institutions, and governmental bodies. Pakistan hosts several key institutions dedicated to

43. Faisal. "Artificial Intelligence for Flood Prediction and Management: Lessons for Pakistan."

advancing AI, including the Sino-Pak Centre for Artificial Intelligence (SPCAI) at the Pak-Austria Fachhochschule Institute of Applied Sciences and Technology, the National Centre for Artificial Intelligence (NCAI) at the National University of Sciences & Technology (NUST), and the Institute of Applied Sciences and Technology (PAF-IAST) in Haripur. These institutions are already collaborating with academia and industries in Austria and China to develop AI technology. Therefore, Pakistan can channel funds from the UN to these institutions to advance the application of AI technology for climate adaptation. Funding can be secured from sources such as the UN Loss and Damage Fund, the UN Development Program (UNDP), or the Adaptation Fund to support the development of AI models for climate adaptation. The second option for Pakistan is to adopt or incorporate existing AI models that are already in use by other countries. Pakistan can engage with these countries to deploy their developed AI models for climate adaptation. For example, Pakistan can establish partnerships with the US, Japan, and Chinese companies and industries to bring their established AI technologies into the country.

The AI models developed in the US can be seamlessly integrated into Pakistan's climate adaptation strategies. For instance, Pakistan can adopt the watsonx.ai model, developed by the US-based company IBM, for flood mapping. This model could be deployed in cities and towns across Pakistan that are frequently affected by floods. By utilizing satellite imagery of flood-affected areas in Punjab, Balochistan, or Sindh, the watsonx.ai model can analyze data to identify high-risk zones, assess the extent of flood damage, and generate detailed flood maps. Satellite images provided by government agencies or international organizations can be processed through the watsonx.ai algorithms to create these maps. This process would enable Pakistan to develop effective flood-risk management strategies promptly. The insights provided by these models could assist emergency responders and policymakers in acting swiftly, whether by constructing flood defenses or issuing early warnings to mitigate the impact of flood disasters. Moreover, the Coastal AI model used by the US can also be applied in the Indus Delta region in coastal Sindh, which is highly vulnerable to sea-level rise.[44]

44. Jennifer Weeks and others., "Sea-Level Rise in Pakistan: Recommendations for Strengthening Evidence-Based Coastal Decision-Making," *Hydrology* 10, no. 11 (October 25, 2023): 205. https://doi.org/10.3390/hydrology10110205.

Since the US employs this model in its coastal regions to protect vulnerable infrastructure, Pakistan can adopt a similar approach. This model can provide valuable information to analyze and predict the types of infrastructure that may be affected by specific sea-level rises. Furthermore, it can support the development of capacity-building measures to prevent potential damage to infrastructure, ensuring better preparedness and resilience against the impacts of climate change.

Pakistan needs to enhance its weather forecasting capabilities to issue early warning systems that can mitigate the impact of climate hazards, such as increased rainfall or extreme heat spells, which pose significant risks to agriculture and crop production. To achieve this, Pakistan can collaborate with Chinese meteorological companies to utilize advanced models like FuXi-Subseasonal, which are capable of predicting long-term weather patterns. This model uses data assimilation and integrates observations from various sources, including weather stations and satellites, into numerical modeling. This allows it to provide accurate weather forecasts for periods ranging from two weeks to a month. By leveraging such advanced forecasting tools, Pakistan can implement "climate-smart strategies" early, enabling farmers and policymakers to take preemptive measures to protect crops and reduce agricultural losses.[45]

In addition to other climate risks, Pakistan's coastlines face the imminent threat of tsunamis, which can originate from local sources and strike within minutes. A 2014 report highlighted that Karachi, one of Pakistan's most populous cities, could be entirely devastated by a tsunami.[46] To address this challenge, Pakistan can deploy the Chinese Fengwu meteorological model, which is highly effective in forecasting tsunamis and other extreme weather events. This model can provide early warnings, giving coastal communities critical time to evacuate and take safety measures. Given the importance of accurate weather forecasting for building climate adaptation strategies, Pakistan can also benefit from incorporating AI models from Japan. Japan has developed an advanced AI model for weather forecasting, known as

45. Mona Nagargade, Vishal Tyag, and Manoj Singh. Climate Smart Agriculture: An Option for Changing Climatic Situation. Plant Engineering, November 2017. https://www.researchgate.net/publication/321313268_Climate_Smart_Agriculture_An_Option_for_Changing_Climatic_Situation.

46. Afp, "Tsunami Could 'Wipe Out' Karachi," *Dawn*, September 10, 2014. https://www.dawn.com/news/1131095

Fugaku. By adopting such models, Pakistan can significantly enhance its efficiency in disaster response management. In addition to forecasting models, Pakistan can also utilize Japanese AI chatbots to coordinate emergency responses. These AI-powered virtual assistants can gather and analyze information from various sources, such as social media, sensors, and satellites. For instance, in disaster-hit areas, when affected communities share their needs, AI chatbots can engage with residents to provide information about the disaster and coordinate with emergency agencies. By facilitating real-time information exchange, these chatbots can streamline disaster response mechanisms, ensuring faster and more effective aid delivery.

Pakistan can pursue these options for the faster integration of AI technology to build climate resilience. Collaborating with the UN, other international organizations, or non-governmental organizations can help Pakistan secure funding to develop and deploy AI technology. Additionally, importing established AI models can significantly accelerate the integration of AI technology to address the climate crisis. However, Pakistan also faces several challenges in incorporating AI technology into its climate adaptation strategies.

Challenges in AI Integration for Climate Adaptation in Pakistan

Pakistan has the potential to incorporate AI technology into its climate adaptation strategies. However, the efficiency of AI depends heavily on critical infrastructure and human expertise, both of which pose significant challenges for Pakistan.[47] Developing and deploying AI technology in the country is hindered by several obstacles. One of the major challenges faced by Pakistan in integrating AI technology is the quality and quantity of data. AI models rely on large volumes of structured, labeled, and high-quality data to function effectively.

However, the limited availability of such data, combined with the prevalence of non-structured and non-labeled datasets, significantly hampers the efficiency and accuracy of AI models. Without access to reliable and well-organized data, AI systems may produce inaccurate predic-

47. Muhammad Hamza Amjad, "Artificial Intelligence (AI) and Policy in Developing Countries," PakistanInstitute of Development Economics (PIDE), 2023. https://file.pide.org.pk/uploads/wb-136-artificial-intelligence-ai-and-policy-in-developing-countries.pdf

-tions or fail to address climate-related challenges effectively.[48] Moreover, the inadequate representation of data reflecting diverse climate change perspectives or localized experiences can significantly affect the formulation and effectiveness of adaptation strategies. Without comprehensive and representative data, AI models may fail to capture the nuanced impacts of climate change in different regions, leading to suboptimal or misdirected strategies. Additionally, AI models rely on human expertise to deliver their maximum potential.[49] Skilled professionals are required to design, train, and interpret AI models effectively, as well as to apply their insights to real-world scenarios. The lack of trained personnel in fields such as data science, AI programming, and climate science further exacerbates the challenges in utilizing AI for climate adaptation. To address this, Pakistan must invest in capacity building and education programs to cultivate a workforce capable of leveraging AI technology effectively.

Pakistan also lacks the requisite infrastructure and facilities needed to produce a workforce skilled in emerging technologies, including artificial intelligence. This shortage of educational and training institutions focused on advanced technological skills hinders the country's ability to develop and deploy AI solutions effectively. Moreover, Pakistan's worsening economic conditions have been a significant impediment to the development and integration of new technologies. Limited financial resources restrict investments in essential infrastructure, research and development, and capacity-building programs.[50] The acquisition of funds from the UN or developed countries to build climate resilience poses another significant challenge for Pakistan due to endemic corruption. Major donors are often reluctant to provide financial aid to the governm-

48. Harshita Jain and Renu Dhupper. "Ai-Enabled Strategies for Climate Change Adaptation: Protecting Communities, Infrastructure, and Businesses from the Impacts of Climate Change," *Computational Urban Science.* https://www.researchgate.net/publication/372458556_AI-enabled_strategies_for_climate_change_adaptation_protecting_communities_infrastructure_and_businesses_from_the_impacts_of_climate_change

49. Muhammad Siddique Ali Pirzada, "Embracing AI in Pakistan's Public Sector Challenges Initiatives, and Future Prospects:", *South Asia Foresight Networ*k, 2024. https://southasiaforesight.org/embracing-ai-in-pakistans-public-sector-challenges-initiatives-and-future-prospects/

50. World Bank Group, "Sustained Reform Commitment is Needed to Overcome Pakistan's Economic Crisis," April 4, 2023. https://www.worldbank.org/en/news/press-release/2023/04/03/sustained-reform-commitment-is-needed-to-overcome-pakistan-s-economic-crisis#:~:text=ISLAMABAD%2C%20April%204%2C%202023%E2%80%94,the%20interbank%20and%20open%20rates

-ent, as allocated funds and resources are frequently misappropriated by influential individuals, preventing the aid from reaching the flood-affected and vulnerable communities who need it most. To overcome this credibility dilemma, Pakistan must make substantial efforts to improve its governance and reduce corruption. The poor governance structure in Pakistan significantly hampers the country's ability to implement efficient strategies to combat climate change. Beyond corruption, policy inconsistency poses a major challenge, as frequent changes or lack of continuity in policies undermine the effective implementation of climate adaptation measures.

Additionally, there is a lack of coordination among various departments responsible for climate change adaptation, resulting in duplicated efforts and inefficiencies in the formulation and execution of climate policies. This fragmentation prevents the development of cohesive strategies and wastes valuable resources. The Ministry of Climate Change and Environment Coordination in Pakistan has often been criticized for taking what many view as "cosmetic initiatives"—superficial measures that fail to address the root causes or provide substantive solutions. Its policymaking has been described as ineffective, lacking the necessary focus, depth, and action-oriented approach to drive meaningful climate adaptation and resilience.

The structural and financial challenges of integrating AI in Pakistan are substantial. However, beyond these hurdles, there is another critical aspect that must be considered before incorporating AI into climate change adaptation strategies: the "AI carbon footprint."[51] According to some forecasts, by 2040, the Information and Communications Technology (ICT) industry could be responsible for approximately 14% of global emissions.[52] AI technology requires substantial computational power, which consumes large amounts of energy and can significantly contribute to global emissions. According to a study, training a single AI model can generate over 626,000 pounds of CO2, an amount equivalent to the emissions produced by five cars over their entire lifetimes.[53]

51. Alokya Kanungo, "The Real Environmental Impact of AI | *Earth.Org,*" Earth.Org, March 5, 2024. https://earth.org/the-green-dilemma-can-ai-fulfil-its-potential-without-harming-the-environment/
52. Kanungo, "The Real Environmental Impact of AI | Earth.Org."
53. Karen Hao, "Training a Single AI Model Can Emit as Much Carbon as Five Cars in Their Lifetimes," *MIT Technology Review*, December 7, 2020.

Currently, as Pakistan works on establishing AI technology across various sectors, it would be prudent to prioritize the incorporation of "green AI technology" to minimize its adverse impact on the climate. Green AI technology emphasizes energy efficiency, sustainability, and reduced carbon emissions in the development and deployment of AI systems. This approach aligns with Pakistan's efforts to address climate change and would ensure that the adoption of AI technology supports rather than exacerbates environmental challenges. Some major tech companies are already leading the way in establishing green AI technology. For instance, Microsoft has committed to using 100 percent renewable energy by 2050, while Google has already achieved a milestone by powering its data centers entirely with renewable energy sources.[54] Given Pakistan's need for funds to support climate adaptation and the integration of AI technology, prioritizing green AI technology would be a strategic choice. By focusing on green AI, Pakistan can simultaneously combat climate change and attract funding from international organizations and climate-focused initiatives.

While AI technology offers promising opportunities for urgent climate adaptation in Pakistan, the challenges associated with its integration cannot be overlooked. Addressing these challenges is critical for ensuring the successful implementation of AI-driven solutions. To overcome these hurdles, Pakistan can collaborate with developed countries and international organizations to facilitate the effective development and deployment of AI technology.

Conclusion

Pakistan, with its diverse geography, is highly susceptible to climate-related vulnerabilities. The impact of climate change is becoming increasingly severe, manifesting in heatwaves, droughts, floods, and glacial lake outbursts. These climate-induced disasters have caused significant damage to the agriculture sector, infrastructure, and the livelihoods of millions across the country. Given the urgency to address these challenges, the integration of AI technology presents a pivotal opportunity for climate cha-

https://www.technologyreview.com/2019/06/06/239031/training-a-single-ai-model-can-emit-as-much-carbon-as-five-cars-in-their-lifetimes/

54. Lucas Joppa, "Made to Measure: Sustainability Commitment Progress and Updates", *The Official Microsoft Blog*, July 16, 2021. https://blogs.microsoft.com/blog/2021/07/14/made-to-measure-sustainability-commitment-progress-and-updates/

-nge adaptation. AI can provide advanced tools for disaster prediction, resource management, and resilience building, which are critical for mitigating the effects of climate change. However, as a developing country, Pakistan is still in the early stages of AI technology development. To maximize the potential of AI for climate adaptation, this research proposes ways through which Pakistan can incorporate AI technology for climate change adaptation.

Collaboration with the UN is a key option for Pakistan to secure financial support for establishing AI technology. The UN's recent initiative, AI4ClimateAction, focuses on climate change adaptation, making it a valuable opportunity for Pakistan to pursue. Pakistan needs to advocate a strong narrative highlighting the devastating effects of climate change on the country to gain support and take full advantage of the UN's actions for climate change. Additionally, Pakistan should develop effective policies to ensure that funds provided by the UN for climate adaptation are utilized in the right direction and achieve maximum impact. Another option for Pakistan is to import already established AI models from other countries, enabling the immediate implementation of proven technologies for climate adaptation without extensive development time.

The study examines certain AI models developed by the US, China, and Japan, which can be utilized in Pakistan for various climate adaptation purposes. For instance, US-developed models like watsonx.ai can aid Pakistan in flood risk management, while the Coastal AI model can identify vulnerable infrastructure affected by rising sea levels. Similarly, China's established models, such as the FuXi Subseasonal model and the Fengwu meteorological model, can help Pakistan improve long-term weather forecasting. By leveraging AI and generating early warning systems, the prediction of floods or extreme rainfall can become significantly more accurate. Japan's AI chatbots can assist in assessing disaster-related information in Pakistan and coordinating with emergency responders for immediate action. However, to fully avail the advantages of AI technology, Pakistan must address domestic obstacles, such as improving infrastructure, enhancing technical expertise, securing sustainable funding, and developing effective governance policies to ensure the efficient use of AI in climate adaptation. Integrating AI technology into Pakistan's climate adaptation strategy presents several challenges , including limited access to technology,

a lack of infrastructure facilities, and a shortage of skilled professionals. Additionally, poor governance and corruption are significant factors that undermine the trust of donor agencies. As one of the most vulnerable countries to climate change, Pakistan must prioritize this issue in its policy-making agenda. Public awareness about the severe impacts of climate change and its serious consequences on livelihoods is crucial for building a collective response to this pressing challenge. Civil society, particularly non-governmental organizations (NGOs), can play a pivotal role in supporting the government's efforts to combat climate change. These organizations can offer technical support and organize capacity-building programs for local communities and government agencies. Such programs can include training in disaster preparedness and climate-resilient infrastructure development.

By adopting these measures, Pakistan has the potential to build a more resilient future, enabling its people to better prepare for and mitigate the disastrous consequences of climate change. While AI is not a silver bullet, it can serve as a powerful tool for climate adaptation when used strategically and in conjunction with other approaches.