CLIMATE CHANGE AND WATER CRISIS, CONSEQUENCES ON AGRICULTURE AND HYDROLOGICAL JUSTICE: CASE STUDY OF PAKISTAN

Muhammad Safian Bajwa
MSc Climate Justice
Glasgow Caledonian University
Scotland (UK)
MBAJWA200@caledonian.ac.uk

Muhammad Imtiaz Khan
Master of Philosophy in Environmental Economics
Pakistan Institute of Development Economics
Quaid-i-Azam University Campus
Islamabad - Pakistan
MKHAN232@caledonian.ac.uk

Karin Helwing
Senior Lecturer
Department of Civil Engineering and Environmental Management
Glasgow Caledonian University
Scotland (UK)
Karin.helwing@gcu.ac.uk

ABSTRACT

Hydrologic justice is necessary in the current time of climate change deteriorating effects. This thesis examines the impacts of climate change on Pakistan's hydrological system and agriculture sector and evaluates the government and stakeholder response to such impacts, with a focus on the water crisis and its implications for hydrological justice. The study uses qualitative research methods to analyse the data collected from various sources, including interviews, and observation. The findings of the research indicate that climate change has led to a reduction in water availability, which has had a significant impact on Pakistan's agriculture sector, particularly small-scale farmers. The frequency of extreme weather events such as droughts and floods has also exacerbated the water crisis, leading to inequitable distribution and access to water resources. The study highlights the importance of hydrological justice in addressing the water crisis in Pakistan. The government, policymakers, and stakeholders must prioritize the needs of vulnerable communities and ensure equitable distribution of water resources. Additionally, promoting sustainable agriculture practices and investing in climate-resilient infrastructure can help reduce the impacts of climate change on Pakistan's hydrological system and agriculture sector. Overall, the study

emphasizes the urgent need for a comprehensive approach to address the water crisis in Pakistan and pursue hydrological justice. The research findings provide valuable insights for policymakers, practitioners, and academics interested in climate change, hydrology, agriculture, and environmental justice.

KEYWORDS: Hydrological justice, Climate Justice, Agriculture, Flood, Water Crisis.

INTRODUCTION

Climate change and hydrological systems are both put in danger by global warming, although the latter can be significantly lessened by tackling the former. Hydrological justice requires collaboration from diverse populations as they share specific water bodies and environmental deterioration frequently damages the residents of neighboring countries. Since simple access to clean water is vital for human endurance, linking climate justice to hydrological justice not only makes access to water more difficult but also ethically and intellectually acceptable, which is something that everybody can understand (Spaid, 2020).

When there is not enough clean, potable water in each area to meet demand, there is a water crisis. Climate change contributes to droughts, floods, and Pollution, abuse of water, population growth, and extensive water usage in agriculture, further contributes to the water scarcity problems (Alam, 2015).One of the nations that is most threatened by climate change is Pakistan.

The use of water by the agriculture industry is among the significant/important uses. Agriculture employs a substantial portion of the labour force in the nation, and its part to the overall gross domestic product (GDP) is close to 19 percent (Economic Survey of Pakistan, 2019-20). The nation also exports finished goods like milk cartons, clothes, and jackets, as well as raw materials like cotton and rice. This dependency on the agricultural sector is crucial and unavoidable for sustainable commerce. More than 95% of Pakistan's freshwater abstractions are allocated to irrigated agriculture, which also accounts for most of the country's economic activity. Domestic and industrial consumers use the remaining 5%. (Ministry of Water Resources, 2018).

The significant amounts of water are required for food production, residential irrigation, crop watering, while other field uses comprise the agricultural sector's use of water (Waqas et al., 2018). Pakistan is an agricultural country whose economy is largely based on agriculture. Certain crops, such rice, cereals, vegetables, spices, and other grains, are very climate-sensitive in Pakistan. It is anticipated that issues with food security may occur due to decreased production, especially in the cultivated food sector, as a result of rising temperatures, changing rainfall patterns, and the resulting water deficit. The water issue affects agriculture and animal rearing not only at the individual level but also at the management levels. Additionally, concerns related to food insecurity and its effects have a direct impact on rural residents' lives and a secondary impact on metropolitan communities. Nearly 61 percent (84 out of 137) of Pakistan's districts have a severe lack of both crop-based and

animal-based sustenance (Rana, et al., 2021). The idea of seeing this problem in the context of climate change brings with it a multipronged strategy to handle the issue seriously. Food insecurity is a significant and greater barrier to the social and economic growth of the country and requires critical scientific investigation.

This study has been done to look at the prevalence of climate justice and hydrological justice in the study area with reference to both water shortage and floods in study area and their implications on the agriculture sector. Moreover, this study to solve the issues in the study area also comes up with some suggestions and recommendations. Hence, the main objectives of this study are to analyze the current situation and trend of climate change and hydrological justice in Sindh and to evaluate the effect of the water crisis on the agriculture sector in the study area.

LITERATURE REVIEW

WATER CRISIS IN PAKISTAN

The World Economic Forum has recognized the water problem as the greatest long-term hazard, and it will have disastrous effects on society (Jafri, 2022). In a similar vein, Pakistan's water system is its lifeline. It provides life and energy. It is crucial to the production of Pakistan's agricultural resources (Asim et.al., 2012). Each year, less than 1000 cubic meters of water are available (Meribole, 2020). Approximately 274 million acre-feet (3379.73 cubic meters) of water will be required by 2025, whereas only 191 million acre-feet (2359.94 cubic meter) will be available (Meribole, 2020). Pakistan has been an ongoing subject of several discussions ever since it attained independence. The most significant problem, however, among the main ones that the country is going through, is the scarcity of water. In accordance with the International Monetary Fund (IMF), Pakistan will be utterly dry and desolate by 2025 if the proper measures are not taken to conserve water (Baloch, 2018). Historical water issues in Pakistan have included everything from dam issues to waterline issues over the whole country. As a result of the ongoing issues, the safety paradigm is also evolving. In recent years, Pakistan has faced serious shortages of water, flooding, and declining water quality. The nation's rising water crisis must be solved if it is to ever achieve stability and progress (Maqbool, 2022). Also, due to severe shortages in electricity supply, Pakistan has seen protracted forced power outages during the last ten years which have varied from 8 to 12 hours daily in urban areas to up to 18 hours daily in rural areas (Valasai et. al., 2017).

Climate change has also had an impact on the current situation. Climate change and unusually hot weather are both impacted by social change (Meribole, 2020). Environmental pollution and global warming have harmed some of Pakistan's glaciers, most notably the Ultar Glacier. The glacier has helped the local valley dwellers grow crops and given fresh water. They are today, nonetheless, denied it in a manner akin to both rural and urban societies (Aiyar and Raina, 2022). Glacier melting, heavy rainfall, and hilly terrain are causing devastating floods which are destroying many farms and homes across the nation. Water is also squandered as a result of flooding.

The province of Sindh located in the southeast of Pakistan. The province is known for having Pakistan's longest river, which is about 1976 miles (3180 km) long. The river enters the Northern Areas (Gilgit-Baltistan) and flows through the North in a southerly direction all along total duration of the country before merging into the Arabian Sea close to the port city of Karachi in Sindh. The river originates in the Tibetan Plateau in the area around Lake Mansarovar in the Tibet Autonomous Region. It then flows a path through the Ladakh district of Jammu and Kashmir. It is Pakistan's main irrigation supply for its rich agricultural lands. With an estimated 207 cubic kilometres (cu km) of annual flow, the river ranks as the 21st largest river in the world in terms of yearly flow. Over the Indus Basin, the climate varies. In the plains of the Sindh and Punjab provinces, it ranges from subtropical arid and semi-arid to temperate sub-humid, and alpine in the hilly highlands to the north. On mountain slopes, annual precipitation can be as much as 2000 mm (water equivalent), ranging from 100 to 500 mm in lowlands (Irfan, et al., 2019).

CONSEQUENCES OF WATER SHORTAGE AND FLOODING ON AGRICULTURE

Water is an essential element that significantly affects the final crop in practically all areas of agriculture. Even the best seeds and fertilizers cannot guarantee that plants will develop to their utmost potential if the proper amount of water is not provided. In order to increase crop productivity, chemical fertilizers are widely employed in modern agriculture. Yet, there is a significant environmental and public health problem related to nutrient drainage from agricultural soil into both surface and groundwater which also impaired water quality (Divya and Belagali, 2012). Water availability must be sufficient for animal husbandry. Of course, water resources are closely related to the existence of fisheries (Malek, et al., 2018).

There are basically three types of floods: river flood, flash flood and drainage flood (Leal, et al., 2018). Nearly 0.2 billion people have reached food security in recent years, yet 0.702 billion people worldwide still suffer severe poverty and food insecurity. Based on the World Bank (annual), chronic malnutrition fell from 40% to 26% as a result of poverty globally (Kleve, et al., 2018). In accordance with a different report from the World Food Security and Nutrition Report. There are still an estimated 0.793 billion individuals who lack access to enough food. Malnutrition will rise and food security will be significantly compromised as a result of climate change (Watts, et al., 2021). Storm strength, frequency, and distribution will rise as Earth warms due to climate change, increasing the likelihood of abrupt disasters including floods, heat waves, storms, and droughts that would impact both economic livelihoods and food security (Hussain and Qamar, 2020).

The literature stressed that finding unified development solutions for consistent advancement on social, ecological, and economic dimensions is still in the early stages (Manzoor, et al., 2022). Since Pakistan's rapid flood episodes have altered the environment, coordinated efforts at all levels of national planning are needed (Hillier and Nightingale, 2013; Sayed and González, 2014). The government currently encounters significant challenges regarding institutional coordination, political mergers, and technique harmonization.

FLOOD MANAGEMENT

One of Pakistan's worst floods in history occurred in August 2010. The most frequent and dangerous natural hazard in the nation are floods. 90% of all people affected by natural disasters experience floods (Naeem, et al., 2021). Nearly 1800 people lost their lives in the recent disaster, and there were tens of billions of dollars in financial losses. Between independence in 1947 and the 2010 flooding, nearly 8000 people perished, and economic damages totaled $10 billion, according to the most recent official statistics (Baig, et al., 2018). These estimates are made at the local administrative level, and it is unknown how accurate they are. Despite the fact that there had not been a significant flood since 1995, the tragic flooding of 2010 showed that flood hazards still existed.

Numerous governmental organizations at the federal and provincial levels are directly or indirectly involved in flood management efforts. Depending on the kind of assistance and services provided, these institutions might be categorized as risk-management institutes. These institutes deal with structural and non-structural solutions, whereas crisis-managing institutes are concentrated on rescue, relief, and rehabilitation activities. (Aslam, 2018).

Pakistan has few and difficult alternatives for managing and mitigating flooding because it is a riparian nation. The emphasis is therefore mostly on the accurate and early warning system. The principal agency for flood forecasting in Pakistan is the Flood Forecasting Division of the Meteorological Department, with assistance from the Water and Power Development Authority (WAPDA). In 1975, a real-time VHF telemetry system was initially developed to predict early flood warnings. 24 rain gauges and 16 river gauges were utilised in the system to gather hydrological data, respectively (Jain, et al., 2018). Another important adaptation strategy is Climate Smart Agriculture (CSA) will require close cooperation with farmers to encourage them to adapt present crop management practices into ones that are more resilient to climate change. The best options for CSA will not be singular or entirely mechanistic; rather, they will involve integrating crop rotation, fertilization methods, seed selection, and irrigation management. To build a resilient CSA farming system, communication and multiple feedback loops would be required. This will allow the techniques to be continuously changed to the varied cropping systems and eco zones. (Lawrence et al., 2013).

The literature highlights that the water crisis in Pakistan is exacerbated by inefficient irrigation practices, over-extraction of groundwater, and inadequate water storage facilities. This has led to increased conflicts between different stakeholders, including farmers, communities, and the government. Additionally, the literature suggests that the impacts of climate change are not distributed equally across different regions and socio-economic groups. Poor and marginalized communities are disproportionately affected by water scarcity, and they often lack access to basic water services and infrastructure. The agricultural sector is particularly vulnerable to the impacts of climate change and water scarcity. The literature suggests that farmers in Pakistan are struggling to adapt to changing weather patterns and water availability, leading to reduced crop yields and income

losses.

METHODOLOGY

As the present study's goals are to examine the theoretical relationship between climate justice and hydrological justice, as well as how these issues are currently playing out in the study area and how they are affecting Sindh's agricultural industry, the qualitative method is employed to answer the study's research questions. The current study uses a descriptive research approach and aims to provide a comprehensive account of the research subject. A variety of techniques, including surveys, questionnaires, observations, and interviews (structured or semi-structured), can be used to collect data. In this study, semi-structured methods are utilized to collect data from respondents to meet the research's objectives since they provide a clear set of instructions as well as consistent and comparable results. In this approach, interview questions were created ahead of time then examined. The data was gathered from local community, government, and non-government officials. For local community stratified sampling has been used, for government officials convenient sampling while for non-government official purposive sampling has been employed. The sample size of the study was 17. Thematic analysis was employed in this study's data analysis since it is the most effective method for analyzing qualitative data. This method assessed the data with distinct themes and patterns that were formed from the data after traversing the different steps of transcribing, familiarization, and coding.

RESULTS AND DISCUSSIONS

WATER CRISIS IN PAKISTAN

The water crisis in Pakistan is a pressing issue that affects the daily lives of millions of people in the country. The local community is acutely aware of this problem and its devastating impact on their lives. Pakistan is one of the most water-stressed countries in the world, with a rapidly growing population and inefficient water management systems. Climate change has further exacerbated this situation, resulting in more frequent and severe droughts, erratic rainfall patterns, and melting glaciers (Akbar, et al., 2021).

The local community in Pakistan is keenly aware of the water crisis and its impact on their daily lives. Many people in Pakistan rely on agriculture for their livelihoods, and the shortage of water has severely affected crop yields and food security. The lack of access to clean drinking water has also led to health problems, particularly among children, who are more vulnerable to water-borne diseases. These findings are supported by the previous literature of (Jafri, 2022). Moreover, the water crisis has led to social and economic conflicts between different communities and provinces, as water is a scarce resource, and its allocation is often politicized.

To address this crisis, the local community in Pakistan is calling for better water management

practices. One of the respondents from the community said that

> '*The government is responsible to avoid such situations and in case of any natural calamity get rid of negative consequences. We are facing so many issues and its time that government should seriously do something for it such as the construction of more dams, rainwater harvesting, and efficient irrigation systems. There is also a need for better governance and transparency in water allocation, with greater involvement of local communities in decision-making processes'.*

WATER SHORTAGE

Water shortage is a major issue in the province of Sindh, which is in the southern part of Pakistan. Sindh is mainly an arid and semi-arid region that experiences low rainfall, making the region heavily dependent on irrigation for agriculture and drinking water (Iqbal, 2010). One of the respondents deliberated that

> '*The main source of water for Sindh is the Indus River, but due to factors such as population growth, rapid urbanization, climate change, and mismanagement of water resources, the water scarcity has become a severe issue in the region'.*

In recent years, the province has faced acute water shortages, with many areas experiencing a lack of drinking water, affecting the health and well-being of the people. The shortage of water has also impacted agriculture, which is the mainstay of the province's economy. The farmers are facing difficulties in growing crops due to the lack of water, which has resulted in low yields, lower incomes, and food insecurity.

One of the respondents from government organization said that

> *'The government of Pakistan has initiated several projects to address the water shortage issue in Sindh, including the construction of dams, reservoirs, and canals. We are working on this to store water as we are aware that water is getting scarce, and it is one of the necessities for living. However, these projects face several challenges, such as inadequate funding, lack of political will, and opposition from various stakeholders. Even if one political party agree and start one project the opposition when come to power comes up with new agendas and interest and that affect the ongoing projects.'*

Flood

Sindh, being a low-lying region, is prone to floods during the monsoon season, which usually occurs from July to September. In recent years, the province has experienced several devastating floods

that have caused significant damage to infrastructure, agriculture, and human life (Kanwal, 2022). The most recent major flood in Sindh occurred in 2020, where heavy monsoon rains caused widespread flooding across the province. The flood affected over 2.4 million people, damaged around 1.2 million homes, and killed over 200 people. The flood also caused damage to crop, livestock, and infrastructure, with estimates suggesting that losses were in the billions of dollars (Pal, et al., 2023).

Le Monde (2022)
https://www.lemonde.fr/en/environment/article/2022/08/30/pakistan-s-catastrophic-floods-in-photos_5995275_114.html

One of the respondents from community said that 'As there are so many coastal areas in Sindh, flood often hit the province, but this recent flood was more damaging than the previous ones. It just not affects the communities near coastal areas but also far-flung areas. The posh areas also come under this flood.

Another respondent said that

> *'There was water on the roads, people get stuck in their homes, they were not able to go to schools, offices. It was very troublesome for residents to manage such an unexpected calamity'.*

The government of Pakistan and international aid agencies responded to the flood by providing relief and assistance to the affected people, including food, shelter, and medical assistance. The authorities also launched efforts to drain the floodwater and rebuild damaged infrastructure, such as roads, bridges, and schools.

EFFECTS OF FLOODING ON AGRICULTURE

Flooding has significant effects on agriculture in Sindh, which is the mainstay of the province's economy. Floods in Sindh usually occur during the monsoon season, which coincides with the Kharif season, the main growing season for crops in the region. The effects of flooding on agriculture in Sindh include crop damage, soil degradation, loss of livestock, disruption of supply chain and food insecurity (Khan, et al., 2022). This recent flood also had serious implications on all of them.

One of the respondents said that

> *'I am a farmer and my livelihood depend on the crops I sell in the market. This recent flood causes extensive damage to crop, including rice, cotton, sugarcane, and vegetables. The floodwater washed away the topsoil, erode the fields, and drown the crops, resulting in significant yield losses'.*

The Nations (2022)
https://www.nation.com.pk/14-Sep-2022/2-84-million-acres-of-crops-affected-in-sindh-by-floods

Floodwaters can also deposit silt and sand, which can change the soil structure and fertility, leading to long-term soil degradation. The deposited sediment can also make it difficult for farmers to plant new crops and can decrease the land's productivity. Our respondent second this point and said that

> *'Although it has been many years after floods, but the situation of fields is still very bad that we are not able grow any crop on it. This flood turned our fertile land into a barren one.'*

Another problem that many residents face is of loss of livestock as floods can also lead to the loss of livestock, including cattle, goats, and buffaloes, which are essential for the livelihoods of many farmers in Sindh.

Kazi (2022)
https://arynews.tv/livestock-loss-floods-in-pakistan/

Besides these floods disrupt the transportation and supply of agricultural inputs and outputs, such as seeds, fertilizers, and crops, leading to higher prices and reduced access to these essential resources. A respondents mentioned that

> *'This flood was widespread and that is the main reason that it affects the transportation so badly. It led to the closure of roads, bridges, and highways due to damage caused by the floodwaters and erosion. Many vehicles get damaged during floods either they breakdown or carried away with flood water. Now farmers do not have cars or trucks to transport the seed and fertilizers.'*

The damage to crops and livestock and lack of resources to grow crops again result in food insecurity, which affects the nutrition and health of the population in the affected areas. A respondent from NGO said that

> *'This flood has devastation consequences on agriculture, it destroyed al the crops farmers were not able to grow and earn their livelihood, there was water everywhere, people were stuck in their homes for many days. All the stored food in their homes finished and they were depriving of food. This flood also economically affects the country and resulted in food shortages. Thus, aid has been called out from various international organizations to dealt with food insecurity'.*

Health Consequences

Floods in Sindh can have significant health consequences for the population in the affected areas. Some of the health consequences of flooding in Sindh include waterborne diseases, vector-borne diseases, respiratory illnesses, mental health, and malnutrition (Ishaque, et al., 2022)

Floods can contaminate water sources, leading to the spread of waterborne diseases such as cholera, typhoid, and hepatitis A. The risk of waterborne diseases is particularly high in areas with poor sanitation and hygiene practices. It can create breeding grounds for mosquitoes and other disease-carrying vectors, leading to the spread of diseases such as malaria, dengue fever, and chikungunya. Moreover, it can cause indoor air pollution due to dampness, mold growth, and exposure to toxic substances. This can lead to respiratory illnesses such as asthma, bronchitis, and pneumonia.

One of the respondents said that

> *'The flood water burst into our streets and house and this water is for sure not clean water. It was contaminated water filled with wrappers, mud, sewage waste and other garbage which was also had bad odour. It stays in the houses and street for several days and all this mess led to several diseases, immense mosquitoes were seen. As me, my family and my neighbours were short of food, we were not eating properly thus our immune systems were weak and resultantly we all fell ill afterwards.'*

Floods can also have mental health consequences, such as stress, anxiety, and depression, particularly for those who have lost their homes, livelihoods, and loved ones (Golitaleb, et al., 2022). Besides all these floods can lead to food shortages and decreased access to safe drinking water, leading to malnutrition, particularly among vulnerable groups such as children and pregnant women. One respondent said that

> *'Me and my wife were trapped in our house for more than two weeks, and my wife was pregnant at that time. We were short of food and her medicines finished including many multivitamins pills. She gets weak lose some weight which become problematic for her at the time of delivery, my baby is also malnourished'.*

Gender Disparities

All the problems are there and faced by all the gender but somehow gender inequality persist in this. Here when it comes to consequences of flood both men and women were the victim of it, however, the extent the to which it affects them differ. Men faced the consequences in terms of finance, most of the respondents were farmer, they lost their yield, their farms were destroyed, lost livestock and vehicles, houses damages, putting more financial pressure on them and mentally destroying their peace. On the contrary, women faced more health consequences.

Other Disparities

One of this inequality can be seen among farm workers and farm owners. Floods lead to significant crop damage, loss of livestock, and damage to infrastructure such as irrigation systems, leading to

a loss of income for both farm workers and owners. However, farm workers were more vulnerable to the loss of livelihoods as they rely entirely on their farm work for their income, while farm owners have other sources of income. Floods also lead to the displacement of both farm workers and farm owners. However, farm workers faced severe consequences due to displacement as they do not have access to adequate shelter or resources in the aftermath of the flood.

Although in previous floods only poor got affected by the consequences of flood but this time poor and wealthy both were the victims of this natural calamity. As this flood affected the agricultural land badly it had serious implications for both poor and wealthy farmers. However, the poor farmers are still in the more devastating phase as compared to wealthy farmers. The wealthy farmers have more resources to cope up with the destruction this flood causes. After all these months, poor farmers are still struggling. One of the respondents highlighted that

> *'I had a small agriculture land on which I grow wheat, had 3 goats which were my source of income. During this flood I lost all of it and the roof of my house also fell. I left my house and moved to a safer area as we have been told due to increased rainfall the flood may happen again. From that time, I am living in a tent which leak often in rain, I still sometime do not have something to eat, and do not have resources to reconstruct my house. I hard from someone that an NGO is providing shelter and food to flood affected people, but they are doing in another city, and I do not have money to move to that city as I am not even sure that either I get shelter there or not. So, I cannot risk losing whatever little I have built here'.*

Moreover, this flood also hit up the wealthy communities as the posh areas like Defence Housing Societies were also floating under floodwater. The people living there were not able to get out of their homes as there were water on the streets. They were also facing electricity loadshedding, their expensive furniture got damaged because of contaminated flood water. All the celebrities living in Karachi were speaking about this issue on their social media accounts as they all were also facing these issues.

Shazia Hassan (2022)
https://www.dawn.com/news/1701690

GOVERNMENT UPTAKE TO WATER CRISIS

Water crisis is a significant issue in Pakistan, and the government has taken several steps to address the issue. One of the respondents from government organization said that

> '*The government has initiated several large-scale projects to construct dams and reservoirs to store water for irrigation, power generation, and domestic use. One of the most significant initiatives is the Diamer-Bhasha Dam, which is under construction in the northern region of Pakistan. The government has also launched several initiatives to conserve water, such as promoting drip irrigation, rainwater harvesting, and water-efficient technologies. Furthermore, the government is also running awareness campaigns to educate people about water conservation, proper water use, and the importance of water for the economy and people's well-being'.*

Another respondent from the government organization deliberated that

'The government is collaborating with international organizations, such as the World Bank, Asian Development Bank, and United Nations Development Programme, to access funding and technical expertise to address the water crisis in Pakistan'.

Despite these efforts, the water crisis in Pakistan remains a significant challenge, and more needs to be done to ensure sustainable water management, equitable distribution of water resources, and long-term solutions to the water crisis.

NGO'S UPTAKE TO WATER CRISIS

Non-governmental organizations (NGOs) in Pakistan are playing an essential role in addressing the water crisis in the country. One of the respondents from NGO said that *'NGOs are taking numerous actions to address the water crisis in Pakistan. Several NGOs are working to develop water infrastructure, such as wells, hand pumps, and rainwater harvesting systems, to provide clean water to communities in need. NGOs are promoting water conservation practices, such as rainwater harvesting, water-efficient farming techniques, and reducing water wastage in households, industries, and institutions. We are also working on this agenda'.*

Parvez Masih (2022)
https://www.lemonde.fr/en/environment/article/2022/08/30/pakistan-s-catastrophic-floods-in-photos_5995275_114.html

Another respondent mentioned that

> '*We are promoting community-based water management approaches, such as water user associations, to ensure equitable water distribution and sustainable use of water resources. Moreover, we are running education and awareness programs to educate people about water conservation, the importance of water for health and hygiene, and the impact of water scarcity on their livelihoods. We are also advocating for policies and regulations that promote sustainable water management, equitable water distribution, and the inclusion of marginalized*

communities in water governance processes'.

CONCLUSION

Based on the research conducted, it can be concluded that climate change has had a significant impact on Pakistan's hydrological system and agriculture sector, leading to an acute water crisis. The increasing frequency of extreme weather events such as droughts and floods has resulted in a reduction in water availability, which has negatively affected crop yields, food security, and the livelihoods of millions of people, especially those living in rural areas. Furthermore, the lack of proper water management policies and practices has exacerbated the water crisis, leading to inequitable distribution and access to water resources.

Hydrological justice is crucial in addressing the water crisis in Pakistan. The government, policymakers, and stakeholders must prioritize the needs of vulnerable communities, including small-scale farmers and marginalized groups, and ensure equitable distribution of water resources. Additionally, promoting sustainable agriculture practices and investing in climate-resilient infrastructure can help reduce the impacts of climate change on Pakistan's hydrological system and agriculture sector. Overall, the findings of this thesis highlight the urgent need for a comprehensive approach to address the water crisis in Pakistan and promote hydrological justice.

REFERENCES

Aiyar, S.S.A. and Raina, V.K., 2022. False Alarm over the Retreat of the Himalayan Glaciers. *Policy Analysis*, (927).

Akbar, M., Khan, S.A., Dilawar, S. and Hassan, M.T., 2021. Water crisis in Pakistan: prospects and implications. *PalArch's Journal of Archaeology of Egypt/Egyptology*, *18*(1), pp.4884-4892.

Alam, K., 2015. Farmers' adaptation to water scarcity in drought-prone environments: A case study of Rajshahi District, Bangladesh. *Agricultural water management*, *148*, pp.196-206.

Asim, M., Vains, A.H., Yousaf, H. and Ramzan, M.A., 2012. Socio economic impact of water crisis on agrarian community in district Faisalabad Pakistan. *Mediterranean Journal of Social Sciences*, *3*(11), p.235.

Aslam, M., 2018. Flood management current state, challenges and prospects in Pakistan: A review. *Mehran University Research Journal of Engineering & Technology*, *37*(2), pp.297-314.

Baig, N., Khan, S., Gilal, N.G. and Qayyum, A., 2018. Do natural disasters cause economic growth? An ARDL bound testing approach. *Studies in Business and Economics*, *13*(1), pp.5-20.

Baloch, S.M., 2018. Water crisis: How is Pakistan running dry.?

Economic Survey 2016-17. Economic Survey of Pakistan 2016-17. Government of Pakistan.

Hillier, D. and Nightingale, K., 2013. *How Disasters Disrupt Development: Recommendations for the post-2015 development framework*. Oxfam International.

Hussain, A. and Qamar, F.M., 2020. Dual challenge of climate change and agrobiodiversity loss in mountain food systems in the Hindu-Kush Himalaya. *One Earth*, *3*(5), pp.539-542.

Iqbal, A.R., 2010. Water Shortage in Pakistan-A Crisis around the Corner. *ISSRA Papers*, *2*(2), pp.1-13.

Irfan, M., Qadir, A., Habib, A., Nadia, J. and Ahmad, S.R., 2019. Vulnerability of environmental resources in Indus Basin after the development of irrigation system. *Irrigation-water productivity and operation, sustainability and climate change*.

Ishaque, W., Tanvir, R. and Mukhtar, M., 2022. Climate Change and Water Crises in Pakistan: Implications on Water Quality and Health Risks. *Journal of Environmental and Public Health*, *2022*.

Jafri, S.Z.H., 2022. A Critical Review Of The Water Crisis In Pakistan. *Webology (ISSN: 1735-188X)*, *19*(2).

Jain, S.K., Mani, P., Jain, S.K., Prakash, P., Singh, V.P., Tullos, D., Kumar, S., Agarwal, S.P. and Dimri, A.P., 2018. A Brief review of flood forecasting techniques and their applications. *International Journal of River Basin Management*, *16*(3), pp.329-344.

Kanwal, M., 2022. Floods in Pakistan: Global Warming or Foreign Nations. *Available at SSRN 4300138*.

Khan, M.R., Barrett-Lennard, E., Punthakey, J., Finlayson, C.M. and Nangraj, M., 2022. Current floods in Pakistan are expected to have continuing adverse effects on food security beyond the current year: a remote sensing perspective.

Kleve, S., Booth, S., Davidson, Z.E. and Palermo, C., 2018. Walking the food security tightrope—

Exploring the experiences of low-to-middle income Melbourne households. *International journal of environmental research and public health*, *15*(10), p.2206.

Lawrence, J., Reisinger, A., Mullan, B. and Jackson, B., 2013. Exploring climate change uncertainties to support adaptive management of changing flood-risk. *Environmental science & policy*, *33*, pp.133-142.

Leal, M., Ramos, C. and Pereira, S., 2018. Different types of flooding lead to different human and material damages: the case of the Lisbon Metropolitan Area. *Natural Hazards*, *91*(2), pp.735-758.

Malek, K., Adam, J.C., Stöckle, C.O. and Peters, R.T., 2018. Climate change reduces water availability for agriculture by decreasing non-evaporative irrigation losses. *Journal of Hydrology*, *561*, pp.444-460.

Manzoor, Z., Ehsan, M., Khan, M.B., Manzoor, A., Akhter, M.M., Sohail, M.T., Hussain, A., Shafi, A., Abu-Alam, T. and Abioui, M., 2022. Floods and flood management and its socio-economic impact on Pakistan: A review of the empirical literature. *Frontiers in Environmental Science*, *10*, p.2480.

Maqbool, N., 2022. *Water Crisis in Pakistan: Manifestation, Causes and the Way Forward* (No. 2022: 60). Pakistan Institute of Development Economics.

Meribole, J., 2020. The Water Crisis In Pakistan. *Borgen Magazine,*

Ministry of Water Resources, 2018. National Water Policy', Government of Pakistan Njuki, E. and Bravo-Ureta, B.E., 2019. Examining irrigation productivity in US agriculture using a single-factor approach. *Journal of Productivity Analysis*, pp.1-12.

Naeem, B., Azmat, M., Tao, H., Ahmad, S., Khattak, M.U., Haider, S., Ahmad, S., Khero, Z. and Goodell, C.R., 2021. Flood hazard assessment for the tori levee breach of the indus river basin, Pakistan. *Water*, *13*(5), p.604.

Pal, I., Ali, F., Mukhopadhyay, A., Tansar, H., Hassan, S.F., Mohanty, A., Islam, H. and Ahmed, S., 2023. Extreme flood analysis for Lower Indus Basin, Pakistan study under disaster risk reduction. In *Multi-Hazard Vulnerability and Resilience Building* (pp. 281-314). Elsevier.

Rana, I.A., Asim, M., Aslam, A.B. and Jamshed, A., 2021. Disaster management cycle and its application for flood risk reduction in urban areas of Pakistan. *Urban Climate*, *38*, p.100893.

Sayed, S.A. and González, P.A., 2014. Flood disaster profile of Pakistan: A review. *Science Journal of Public Health*, *2*(3), pp.144-149.

Spaid, S., 2020. Tying Climate Justice to Hydrological Justice. *Rivista di estetica*, (75), pp.143-163.

Valasai, G.D., Uqaili, M.A., Memon, H.R., Samoo, S.R., Mirjat, N.H. and Harijan, K., 2017. Overcoming electricity crisis in Pakistan: A review of sustainable electricity options. *Renewable and Sustainable Energy Reviews*, *72*, pp.734-745.

Waqas, M., Nizami, A.S., Aburiazaiza, A.S., Barakat, M.A., Ismail, I.M.I. and Rashid, M.I., 2018. Optimization of food waste compost with the use of biochar. *Journal of environmental management*, *216*, pp.70-81.

Watts, N., Amann, M., Arnell, N., Ayeb-Karlsson, S., Beagley, J., Belesova, K., Boykoff, M., Byass, P., Cai, W., Campbell-Lendrum, D. and Capstick, S., 2021. The 2020 report of the Lancet Countdown on health and climate change: responding to converging crises. *The*

lancet, *397*(10269), pp.129-170.