Cross Current International Journal of Agriculture and Veterinary Sciences
Abbreviated Key Title: Cross Current Int J Agri Vet Sci
ISSN: 2663-2454 (Print) & Open Access
DOI: https://doi.org/10.36344/ccijavs.2025.v07i05.003

Volume-7 | Issue-5| Sep-Oct, 2025 |

Review Article

The Paradox of Progress: How Infrastructure Enables Development Yet Exacerbates Flood Disasters in Pakistan and Nigeria

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| **Received:** 25.08.2025 | **Accepted:** 14.10.2025 | **Published:** 25.10.2025 |

Abstract: Flood disasters in developing countries are not solely driven by climate change but are often intensified by poorly planned infrastructure and weak water governance. This paper explores how infrastructural systems, originally designed to enable development, have exacerbated flooding in Pakistan and Nigeria'. Drawing on academic literature, government reports, and disaster assessments, the study analyzes three major events; Pakistan's 2010 and 2022 floods and Nigeria's 2022 flood to evaluate the paradox of progress where infrastructure becomes a source of vulnerability. In Pakistan, the canal irrigation network established in the 1840s and later expanded under the Indus Basin Development Programme disrupted natural river dynamics, contributing to over 1,700 deaths and the displacement of nearly 8 million people in 2022. In Nigeria, downstream flooding linked to water releases from Cameroon's Lagdo Dam caused over 500 deaths, displaced approximately 790,000 people, and affected more than 1.4 million nationwide. Findings reveal that mismanaged infrastructure through levee breaching, sediment buildup, insufficient maintenance, and poor alignment with natural hydrology transforms manageable rainfall into humanitarian disasters. The paper recommends hydrologically sensitive infrastructure design, wetland and mangrove conservation, equitable land-use enforcement, and basin-wide water governance.

Keywords: Flood disasters, Infrastructure development, Water resource management, Hydrological systems, Agricultural vulnerability, Climate change and developing countries.

INTRODUCTION

Climate change is widely recognized as an existential threat, with developing countries often bearing its most severe consequences due to their limited adaptive capacity (Khan *et al.*, 2021; Millner & Dietz, 2015). Flood events in Pakistan (Fahad & Wang, 2020; Hussain *et al.*, 2020) and Nigeria (Agada, 2020) exemplify this vulnerability. However, studies indicate that inadequate, poorly designed, or deteriorating infrastructure has further intensified the impacts of such disasters (Syvitski & Brakenridge, 2013; Mazawaje *et al.*, 2014). Although infrastructure is essential for economic growth and social development, its mismanagement and poor design can significantly heighten risks to human life, livelihoods, and ecosystems. In countries such as Pakistan and Nigeria, infrastructural development has, in several cases, transformed otherwise manageable floods into catastrophic events.

Pakistan, with a population exceeding 220 million, is traversed by five major rivers (Hashmi *et al.*, 2012). The country has experienced catastrophic flooding, notably in 2010 and 2022, resulting in extensive loss of life and property (Waseem *et al.*, 2022). Scholars attribute these floods not only to climate change but also to the extensive canal irrigation system established during the British colonial era and later expanded under the Indus Basin Development Programme (Syvitski & Brakenridge, 2013). This study examines the complex interconnections between infrastructure development, ecological systems, and social resilience in both Pakistan and Nigeria.

Flooding in Sindh Province and Its Social Impacts

Sindh is the second-largest province of Pakistan by population (Pakistan Bureau of Statistics, 2017), and is bordered to the north by Punjab Province, to the west by Balochistan Province, to the east by India, and to the south by the Arabian Sea (Azad *et al.*, 2003). The province extends approximately 580 km in length and

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Journal homepage:
https://www.easpublisher.com/

Citation: Glory Ade Iorliam (2025). The Paradox of Progress: How Infrastructure Enables Development Yet Exacerbates Flood Disasters in Pakistan and Nigeria. *Cross Current Int J Agri Vet Sci, 7*(5), 130-139.

280 km in breadth, with about 930 km of the Indus River flowing through it (Kazi, 2014). Sindh's inhabitants are predominantly engaged in agriculture, with their livelihoods and economic progress closely tied to irrigation water supplied by the Indus River. Pakistan is among the world's leading rice exporters (USDA, 2022). Major field crops cultivated in Sindh include wheat, cotton, rice, and sugarcane, which together account for approximately 68% of the total cropped area (Azad *et al*., 2003).

This southeastern province receives an annual precipitation ranging from 100–500 mm in the lowlands to about 2,000 mm in the mountainous areas. The Indus River, the longest in Pakistan, serves as the primary source of irrigation for the nation's fertile agricultural lands, with an estimated annual flow of around 207 cubic kilometers, making it the 21st largest river in the world in terms of annual discharge (Uddin *et al*., 2013).

Pakistan has a long history of flooding; notably, the 2010 floods affected approximately 21 million people and resulted in more than 1,700 deaths, a scale of destruction reportedly surpassing the combined impacts of the 2004 Asian tsunami, the 2005 Kashmir earthquake, and the 2010 Haiti earthquake (Mustafa & Wrathall, 2011). In 2022, floods submerged roughly one-third of Pakistan, affected approximately 33 million people, displaced nearly 8 million, and resulted in over 1,700 deaths (UNICEF, 2022; World Bank, 2022). Agricultural losses were catastrophic. About 45% of Pakistan's cropland was washed away, severely threatening food security and livelihoods, particularly in Sindh Province, where much of the damage occurred. Infrastructure such as dams, barrages, canals, and levees often amplified the intensity of flooding rather than mitigating it (Mustafa & Wrathall, 2011). For instance, the deliberate breaching of Lake Manchar embankments—a measure intended to divert water away from populated areas—caused further devastation and contributed to over 500 deaths in Sindh (Kurtzer & Abdullah, 2022).

Infrastructure

Infrastructure encompasses the physical and organizational frameworks that support and enable social and economic activities within society. It comprises the essential systems and facilities that allow communities to function effectively and sustain economic and social development. Examples of such essential facilities include bridges, railways, dams, and water supply or irrigation systems—collectively known as physical infrastructure, which is the primary focus of this study. Infrastructure constitutes built networks that facilitate the flow of goods, people, and ideas, enabling their exchange across space (Larkin, 2013). As physical forms, infrastructures shape the nature of networks, their speed, direction, temporal dimensions, and susceptibility to breakdowns (Larkin, 2013; Star, 1999). In addition, Blackridge Research and Consulting (2022) define infrastructure as the collection of services and facilities that enhance economic productivity and promote national or regional growth. Infrastructure can also be categorized as institutional, personal, or material (Buhr, 2003). Irrespective of classification, infrastructure serves a fundamentally connective role, linking people of varied social and economic backgrounds to each other and to their environment (Graham & Marvin, 2001).

Infrastructure, Modernization, and the Narrative of Progress

Infrastructure is widely regarded as a hallmark of progress and modernity. Societies frequently celebrate the construction of new infrastructure projects, even when their actual value to local communities remain uncertain or when such projects risk producing more harm than benefit. The association between infrastructure and civilization has become deeply ingrained, reinforcing the belief that development and progress are inseparable from infrastructural expansion (Larkin, 2013).

This perception is rooted in a long-standing historical connection between infrastructure and modernization, which makes it difficult to question whether all infrastructural investments genuinely improve societal well-being. Governments and leaders often pursue large-scale projects not solely out of necessity or in response to public needs but sometimes as symbols of modernization and national prestige. Yet, such projects do not always justify their social or environmental costs, raising critical questions about the true purposes and beneficiaries of infrastructural development.

Scholars further argue that the political and symbolic dimensions of infrastructure frequently overshadow its practical utility. Graham and Marvin (2001) highlight how infrastructural networks are used to project state power, attract foreign investment, or symbolize national advancement while simultaneously producing social inequalities through uneven access and exclusion. Similarly, Buhr (2003) notes that infrastructure, though vital for economic growth, can reproduce disparities when planning decisions prioritize visibility and prestige over community needs and ecological sustainability.

Expanding on this critique, Wagner (2022) situates large-scale infrastructural projects within the broader narrative of modernity, contending that while such projects symbolize innovation and state capacity, they often introduce new socio-ecological vulnerabilities. This perspective underscores that infrastructure is not merely a neutral instrument of progress but rather a manifestation of the political, economic, and cultural agendas embedded within contemporary development paradigms.

Purpose and Rationale of Infrastructure

Infrastructure serves multiple functions, including enhancing agricultural productivity and promoting economic growth objectives evident in both case studies examined here. According to Uddin *et al*. (2013), Sindh Province is predominantly arid, with limited vegetation except in the irrigated Indus Valley. To support agricultural expansion, an extensive irrigation system was established to channel water into otherwise dry regions. Beyond agricultural purposes, infrastructure development in Pakistan has also been driven by economic motivations. Following the signing of the Indus Waters Treaty between Pakistan and India in 1960 to resolve transboundary water disputes (Kazi, 2014), financial institutions and donor agencies began promoting and funding large-scale projects such as the Indus Basin Development Programme (IBDP) to stimulate national economic growth (Mustafa & Wrathall, 2011).

Infrastructure, Displacement, and Development

Although infrastructure projects are typically designed to provide essential public services, they often entail the displacement of people, settlements, and livelihoods. Such projects can lead to forced migration, severing communities' social and economic ties to ancestral lands (Oliver-Smith, 2006). This phenomenon, widely recognized as *development-forced displacement and resettlement* (DFDR), describes situations where populations are compelled to relocate to make way for projects justified as being in the public interest (Oliver-Smith, 2006; Terminski, 2013). Closely related to DFDR is the concept of *emplaced displacement*, which captures how large-scale infrastructural interventions gradually detach people from their sense of place, identity, and belonging even when they are not physically relocated (Ali, 2022; Ahmad, 2022). In both cases, displacement is not merely a spatial process but a socio-ecological and political one where development alters landscapes, disrupts livelihoods, and reshapes relationships between people and their environments. Together, these frameworks emphasize that infrastructure development must be understood not only as a technical or economic endeavor but also as a process deeply entangled with power, inequality, and environmental transformation.

Large-scale infrastructure projects such as dams, canals, and highways frequently require clearing land, resettling communities, or flooding inhabited zones. Those displaced often lose access to land, employment, social networks, and cultural heritage. As Picciotto (2013) observes, communities affected by infrastructure development may experience long-term economic marginalization when their physical and financial assets are lost. Moreover, Nicoletti *et al*. (2022) emphasize that the benefits of infrastructure investment are rarely distributed equitably. Marginalized or remote communities may bear the costs of displacement while receiving little of the advantages such as access to new markets or public services, thereby reinforcing existing social and spatial inequalities.

Changes in land use also amplify risks associated with displacement. Infrastructure that alters hydrology or land cover such as dams, canalization, or embankments can heighten vulnerability to flooding and erosion, forcing recurrent or more severe relocations of downstream or adjacent communities (Vestby *et al*., 2024). Forced displacement further disrupts community cohesion, social capital, and local governance structures, making recovery and reintegration particularly difficult (Joint Data Centre on Forced Displacement, 2020). Even in planned resettlement programs, compensation is often inadequate, and relocated populations rarely regain their previous living standards, leading to long-term vulnerability (Picciotto, 2013).

Additionally, displacement can also occur following the maintenance failure or eventual breakdown of infrastructure, compounding the risk faced by surrounding populations. Although infrastructure can stimulate economic development and expand livelihood opportunities, it simultaneously introduces new threats to social stability and human security. For example, following completion of the Indus Basin Development Programme (IBDP) in 1970, Pakistan's agricultural production increased substantially; however, catastrophic floods in 1973 overwhelmed the canal system, exposing the limitations of risk management and institutional preparedness (Mustafa & Wrathall, 2011). Approximately one million people in Sindh Province were displaced from inundated villages, seeking refuge in higher elevations, urban centers, or internally displaced persons (IDP) camps (Mustafa & Wrathall, 2011). The social and spatial displacements resulting from infrastructure development are mirrored by their environmental consequences. Nowhere is this interplay more evident than in Sindh Province, where decades of river engineering, canal construction, and water diversion schemes have fundamentally altered hydrological systems. These interventions, while aimed at promoting agricultural productivity and economic stability, have disrupted the natural flow regime of the Indus River, amplifying flood risks and exposing local populations to recurrent disaster cycles. The following section examines the role of infrastructure in shaping Sindh's vulnerability to catastrophic flooding and its broader implications for environmental management and human security.

The Role of Infrastructure in Sindh Flooding

Flooding in Pakistan is frequently triggered by intense monsoon rainfall, often linked to climate variability, which overwhelms rivers and causes them to exceed their natural banks, devastating nearby communities. However, these disasters cannot be explained by climatic factors alone. The country's extensive water management and river engineering systems developed over more than a century have also played a significant role in intensifying the magnitude and frequency of floods.

As documented by Mustafa and Wrathall (2011), British engineers constructed the world's largest canal irrigation network in Sindh during the 1840s, transforming the lower Indus Basin to enhance agricultural productivity. This colonial-era system, beginning with the Upper Bari Doab Canal, laid the foundation for Pakistan's present irrigation infrastructure. After independence in 1947, successive governments expanded these systems through the construction of new dams, barrages, weirs, and distributary canals. While these projects supported irrigation and economic growth, they also disrupted the Indus River's natural hydrological regime, at times preventing its waters from reaching the Arabian Sea.

Pakistan is among the most hydrologically engineered countries in the world, with approximately 43% of its population directly dependent on agriculture and about 80–82% of its cultivated land under irrigation (Mustafa & Wrathall, 2011; FAO AQUASTAT, 2020). The 1960 Indus Waters Treaty signed between India and Pakistan, facilitated the reallocation of the Indus River system and accelerated massive infrastructure development across the basin. This led to the construction of major dams, barrages, and an extensive canal irrigation network that transformed Pakistan's rural landscape into one of the largest contiguous irrigated systems in the world.

Although these interventions aimed to stabilize water availability and promote agricultural growth, they significantly altered sediment transport, disrupted natural floodplains, and reduced the river system's ability to absorb and dissipate seasonal flood pulses. Consequently, these hydrological and geomorphological changes have amplified both the frequency and severity of flood disasters across the Indus Basin (Syvitski & Brakenridge, 2013; Mustafa & Wrathall, 2011).

Following the catastrophic 2010 floods, it became evident that this model of river engineering was unsustainable. Studies revealed that many elements of the Indus Basin's infrastructure—dams, barrages, canals, and levees—had amplified the severity of flooding rather than containing it (Mustafa & Wrathall, 2011). Experts argued that the rigid management of river systems, including the construction of embankments and artificial channels, neglected the natural rhythms and floodplain dynamics of the Indus. As a result, infrastructure designed to control water ultimately intensified hydrological hazards. Some flood events were caused by overtopped levees, while others were worsened by deliberate breaching of embankments by irrigation authorities attempting to protect regulatory structures from collapse (Mustafa & Wrathall, 2011).

Supporting these conclusions, multiple studies—including Mastoi *et al*. (2008), Azad *et al*. (2003), and Uddin *et al*. (2013) confirm that water management infrastructure has contributed significantly to flood disasters in Sindh and across Pakistan. Collectively, these findings highlight how human interventions, intended to control nature, can instead magnify environmental vulnerability, transforming hydrological systems into sources of risk.

The intensification of flooding in Sindh underscores the broader social and environmental inequities embedded within infrastructural development. The same engineering projects that enabled large-scale irrigation and agricultural expansion have also deepened the vulnerability of marginalized populations residing along the Indus floodplains. Poor communities, lacking political influence or access to safe relocation options, often bear the brunt of structural failures and deliberate management decisions such as the breaching of embankments. These outcomes reflect what scholars describe as *environmental injustice*—where the social costs of infrastructural and environmental mismanagement are disproportionately borne by those with the least capacity to respond. Consequently, the intersection of hydrological modification, governance decisions, and poverty in Sindh transforms what were intended as tools of progress into enduring sources of displacement and social inequity.

Why the Province of Sindh?

This review focuses on Sindh Province due to its distinctive hydrological and infrastructural characteristics. Sindh is traversed by the 3,000-kilometer-long Indus River—one of Asia's largest river systems—with an estimated catchment of one million square kilometers (Kazi, 2014), which makes it highly prone to riverine flooding. The province also contains Lake Manchar, Pakistan's largest natural freshwater lake (Mastoi *et al*., 2008; Sindh Irrigation Department, n.d.). The dense network of irrigation canals in Sindh exemplifies the scale of hydraulic engineering in Pakistan: below its major barrages the system comprises 14 main feeders and approximately 1,462 branch canals, distributaries and minors, with more than 95% of irrigation water delivered via canals (Azad *et al*., 2003). Sindh also hosts three of Pakistan's largest irrigation barrages — Sukkur (commissioned 1932), Kotri and Guddu — together forming one of the country's most extensive irrigation networks (Uddin *et al*., 2013; Azad *et al*., 2003). Although designed to stabilise water availability, these modifications significantly altered sediment dynamics and reduced the river system's capacity to absorb flood pulses.

Population Most Affected by Flooding in Sindh

Flooding affects people across all social strata, but vulnerability is unevenly distributed. Individuals and communities with low socioeconomic status experience disproportionately severe impacts because of their limited adaptive capacity and exposure patterns. Studies show that low-income earners are likely to lose more than twice as much income as wealthier households following flood events (Brouwer *et al*., 2007), thereby pushing them deeper into poverty (Winsemius *et al*., 2018). Poor households often settle in flood-prone areas not out of ignorance of the risks, but because such vulnerable zones typically offer more affordable housing compared to safer, higher-elevation areas. Consequently, they face recurrent exposure, limited political influence, and lower access to post-disaster recovery assistance. It is reasonable to infer that few individuals would voluntarily remain in high-risk areas if they had the resources to relocate or the social capital to influence policy decisions.

Low-Income and Resource-Constrained Communities

Socioeconomic status is a major determinant of exposure and resilience to disasters such as flooding (Smith, 2006). Poorer rural farming communities suffer not only direct income losses but also the inability to purchase essential food and non-food items (Echendu, 2020). Many live in informal settlements or slums near rivers or drainage channels, where their exposure to flood hazards is greatest (Winsemius *et al*., 2018). Their limited savings and restricted access to credit further increase their vulnerability and mortality risk during and after flood events (Kundzewicz *et al*., 2002; Jongman *et al*., 2015).

Riverine Communities

Many settlements in Sindh are located on river terraces or lowlands. Urban migrants often occupy high-risk floodplains because of land scarcity and poverty. The catastrophic flood of 2010 illustrated how floods routinely affect communities along the five major rivers of the Indus Basin (Mustafa & Wrathall, 2011). Sindh's location along the Indus River inherently increases its flood vulnerability, while cities such as Sukkur—situated on the river's banks—are particularly exposed to inundation (Uddin *et al*., 2013).

Marginalized Groups

Discrimination against small farmers and politically marginalized groups exacerbates the social dimensions of flood vulnerability. Pakistan's water management system has often excluded these populations from decision-making, leaving them most exposed to inundation (Mustafa & Wrathall, 2011). Reports suggest that in some cases, embankments were deliberately breached to protect the property of influential landowners and politicians, redirecting floodwaters toward poorer communities. This practice highlights the intersection of power, inequality, and environmental risk, where the state's protection is unevenly distributed (Rodriguez, 2010).

Sindh's flood situation illustrates the paradox of infrastructural development in flood-prone regions. While irrigation networks and hydraulic structures have underpinned agricultural productivity and economic growth, they have also deepened exposure to flooding and social inequality. The convergence of colonial legacies, modern engineering, and uneven governance has transformed water from a life-sustaining resource into a driver of displacement and vulnerability. Sindh's experience demonstrates that sustainable infrastructure must be rooted in ecological understanding, equitable governance, and community resilience, principles that are equally vital in other contexts such as the Nigerian floodplains examined in the following section.

Infrastructure and Flooding in Benue State, Nigeria: Lagdo Dam Tragedy

As in Sindh, the Nigerian experience illustrates how infrastructural development though intended to promote modernization and economic growth can inadvertently intensify environmental hazards and deepen social vulnerability. Recurrent flooding along the Benue and Niger Rivers exemplifies the intersection of weak governance, rapid population expansion, and unsustainable hydrological engineering practices. The construction of large dams such as the Lagdo Dam in Cameroon has altered natural river flow regimes and intensified downstream flooding in Nigeria's Benue Basin. Poor maintenance of drainage networks, encroachment on floodplains, and inadequate urban planning have compounded these risks, transforming what were once seasonal inundations into devastating humanitarian crises. Examining Nigeria's infrastructural and policy frameworks provides critical comparative insight into how developmental ambitions, when not aligned with ecological realities, can reproduce the very vulnerabilities they seek to overcome.

The experience of Benue State, Nigeria, mirrors that of Sindh Province in Pakistan, illustrating how infrastructure can intensify rather than mitigate natural hazards, and both regions are agriculturally dependent. Benue State, known as Nigeria's "food basket," produces yams and other staple crops, yet remains highly vulnerable to riverine flooding. Benue is traversed by one of Nigeria's major rivers, the Benue River, whose extensive floodplain spans approximately 181,000 hectares (Abah & Petja, 2017). The state has experienced recurrent floods; many linked to the operation of the Lagdo Dam in neighboring Cameroon. This case demonstrates how infrastructural developments, including those across national borders, can amplify local vulnerabilities, triggering widespread displacement, livelihood loss, and environmental degradation.

Geographical and Environmental Setting

Benue State is in Nigeria's North-Central region, between longitudes 7°47′ and 10°00′ E and latitudes 6°25′ and 8°08′ N. The state receives an average annual rainfall of approximately 1,557 mm, ranking among Nigeria's wetter inland regions (DataAfrica, 1990–2015). Two distinct climatic seasons prevail: a wet season (April–October) and a dry or harmattan season (November–March). Vegetation consists of rainforest and Guinea savanna mosaics. The Benue River floodplain, covering about 181,000 ha, represents a large area at risk of inundation rather than merely denoting river length (Abah & Petja, 2017). The Benue River, a major tributary of the Niger River, extends roughly 1,400 km and drains an estimated 319,000 km² catchment (Abah & Petja, 2017; FAO AQUASTAT, 2020).

Topographically, Benue lies mostly between 100 m and 250 m above sea level, featuring gently undulating terrain interspersed with inselbergs, knolls, and lateritic ridges. Some areas exhibit steep slopes and deeply incised valleys (Agada, 2020). The state covers approximately 34,059 km² and had an estimated population of 5.79 million in 2019 (National Bureau of Statistics, 2020). Benue State comprises 23 local government areas characterized by widely dispersed rural settlements and a few nucleated communities clustered along fertile river valleys, floodplains, and major markets. The state is primarily drained by the Benue River—one of Nigeria's principal waterways—along with smaller tributaries such as the Katsina-Ala River. The proximity of many settlements to these rivers has historically provided fertile land and irrigation opportunities but has also heightened exposure to flood hazards. Owing to its fertile soils, the economy is predominantly agrarian, producing yams, rice, cassava, maize, beans, soybeans, millet, sorghum, cocoyam, groundnuts, sesame, melon, tomatoes, and various fruits—hence the title "Food Basket of the Nation." Farming, livestock rearing, and fishing dominate livelihoods across the Benue Trough, which also shares an international boundary with Cameroon.

Lagdo Dam and the 2022 Flood Devastations in Nigeria

Although Benue State is endowed with extensive surface water resources, including River Benue, River Katsina-Ala, and several streams and lakes, water management remains a critical challenge. Despite this hydrological wealth, Nigeria still lacks a standardized water management framework that effectively balances resource utilization with flood prevention (Ichite & Yusuf, 2022). Many communities continue to experience significant water scarcity, particularly with respect to potable water. During the dry season, wells, lakes, streams and boreholes often run dry, forcing women and children especially to travel long distances in search of untreated water sources such as rivers. This paradox of water abundance amid scarcity reflects the gap between natural resource availability and infrastructural capacity. The underlying challenge is not the absence of water itself but rather the inadequate management, treatment, and distribution infrastructure required to ensure reliable access to safe drinking water (World Bank, 2021). Consequently, water insecurity in Benue is both hydrological and institutional, driven by the lack of coordinated governance and maintenance of existing facilities. This dual condition reveals the complex interconnections between infrastructure, environmental variability, and public welfare at both regional and national levels.

A key factor exacerbating flood risks is the Lagdo Dam in northern Cameroon, constructed between 1977 and 1982 by the China International Water and Electric Corporation (CWE) for irrigation and hydropower generation (Okereke & Fombo, 2022). The dam, which measures approximately 308 m in length, 40 m in height, and 9 m in thickness, with a reservoir surface area of 586 km² and an installed capacity of 72 MW (Nonki *et al*., 2021), plays a crucial role in regulating flows of the Benue River system. However, periodic water releases from the dam have been repeatedly associated with downstream flooding in Nigeria's Benue Basin, particularly when combined with extreme rainfall events.

During the catastrophic 2022 floods, Nigeria experienced one of its most devastating hydrological disasters in recent history. More than 500 lives were lost, 790,254 people were displaced, 1,546 individuals sustained injuries, and a total of 1,411,051 people were affected nationwide. An estimated 44,099 houses were partially damaged and 45,249 destroyed (AllAfrica, 2022; Davies, 2022). In addition, approximately 76,168 hectares of farmland were partially damaged, and 70,566 hectares were entirely lost. Water levels at Lokoja and Makurdi along the Niger and Benue Rivers rose about 11 percent above those recorded during the 2012 floods (THIS DAY, 2022; NEMA, 2022). Reports (e.g., THIS DAY, 2022; Nonki *et al*., 2021) indicate that the catastrophe resulted from a combination of heavy precipitation, emergency water releases from the Lagdo Dam, sediment accumulation within the reservoir, and the absence of Nigeria's planned complementary structure, the Dasin Hausa Dam which was intended to regulate inflows from Cameroon but was never constructed, despite Nigeria's earlier commitment to its development. Additionally, weak transboundary coordination mechanisms, limited warning systems, inadequate drainage infrastructure, and the encroachment of human settlements into flood-prone zones have all amplified flood exposure and social vulnerability. Collectively, these factors underscore the urgent need for coordinated basin-wide management and improved bilateral agreements between Nigeria and Cameroon to prevent similar disasters in the future.

The experience of Benue State reflects the broader argument that infrastructure, while intended to enhance development and resilience, can inadvertently magnify environmental and social risks when poorly planned or maintained. Much like Sindh Province in Pakistan, Benue's vulnerability is compounded by its dependence on large-scale water infrastructure that alters natural hydrological regimes. The cross-border influence of the Lagdo Dam exemplifies how infrastructural decisions made outside national boundaries can have far-reaching local consequences. Together, these cases highlight the paradox of development: that modern infrastructure without adequate environmental governance and transboundary coordination may transform natural variability into recurrent disaster. Addressing these challenges requires integrated water management policies, early warning systems, and regional cooperation that prioritize human and ecological security alongside economic growth.

Integrated Recommendations for Flood Mitigation and Infrastructure Management in Developing Regions

1. Align Infrastructure Development with Natural Hydrology

Both Pakistan's Sindh Province and Nigeria's Benue State demonstrate the dangers of constructing infrastructure that disrupts natural water flow. In Sindh, canal and barrage networks have altered the Indus River's floodplain dynamics, while in Benue, uncoordinated dam releases and inadequate drainage amplify inundation risks (Mustafa & Wrathall, 2011; Ichite & Yusuf, 2022). Future infrastructure should be designed in harmony with natural hydrological systems through comprehensive watershed planning, geomorphological assessments, and community-based input to minimize maladaptive outcomes.

2. Strengthen Transboundary and Intergovernmental Water Governance

Weak institutional coordination contributes significantly to flooding in both contexts. The absence of a bilateral regulatory mechanism between Nigeria and Cameroon for Lagdo Dam operations mirrors the fragmented management of the Indus Basin among Pakistan's provinces (Mustafa & Wrathall, 2011). Establishing formal transboundary water-sharing agreements, supported by real-time data exchange, early warning systems, and joint emergency response protocols, is essential to reduce downstream flood hazards.

3. Integrate Ecosystem-Based Solutions into Flood Management

Nature-based interventions such as wetland conservation, reforestation, and mangrove restoration offer cost-effective alternatives to purely structural flood controls (Barnes, 2022). In Sindh, conserving Ramsar wetlands and expanding mangrove forests along the Indus Delta would enhance water infiltration and reduce storm surges (Azad *et al*., 2003; McInnes, 2011). Similarly, reforestation and riparian vegetation restoration along the Benue River could stabilize soils, slow runoff, and mitigate erosion. These approaches provide dual benefits of ecological restoration and disaster risk reduction.

4. Enforce Land-Use Planning and Floodplain Zoning

Unregulated development in flood-prone areas is a recurring challenge in both regions. Illegal settlements along waterways in Sindh and within the Benue River floodplain obstruct natural drainage and increase exposure to floods (Kurtzer & Abdullah, 2022; Abah & Petja, 2017). Enforcing zoning regulations, relocating high-risk communities with fair compensation, and adopting inclusive urban planning will reduce vulnerability and protect critical infrastructure.

5. Improve Drainage, Sediment Management, and Maintenance Culture

Aging and poorly maintained and designed drainage and irrigation infrastructure exacerbate flood hazards in both Pakistan and Nigeria. Sedimentation in the Indus and Benue Rivers reduces channel capacity, while neglected canal systems and blocked drains cause overflow during heavy rainfall (Azad *et al*., 2003). Regular dredging, inspection, and desilting—supported by hydrological modeling and environmental assessments—should be institutionalized as part of an adaptive water-management strategy.

6. Enhance Institutional Capacity and Public Awareness

Institutional weaknesses, data limitations, and insufficient community engagement remain major obstacles. Flood preparation can be strengthened through capacity-building for local disaster agencies, training for water engineers, and the establishment of decentralized early warning systems. Public education campaigns, especially targeting farmers and informal settlers should promote risk awareness, maintenance practices, and safe land-use behaviors.

7. Ensure Equitable Access to Water and Livelihood Resilience

Paradoxically, both regions experience water abundance yet suffer water insecurity. In Benue, access to potable water remains limited despite vast surface resources; in Sindh, irrigation benefits are unevenly distributed, favoring wealthier landowners (Mustafa & Wrathall, 2011). Policies must prioritize equitable water distribution, sustainable irrigation practices, and livelihood diversification to prevent environmental stressors from deepening social inequality.

CONCLUSION

The experience of both Sindh Province in Pakistan and Benue State in Nigeria reveals a critical truth: infrastructure, when developed without ecological sensitivity or institutional coordination, can transform manageable hydrological systems into persistent disasters. In Sindh, the extensive canal and barrage networks designed to control the Indus River have instead disrupted natural floodplains, increased sedimentation, and weakened the capacity of ecosystems to absorb floodwaters. Similarly, in Benue, the absence of the Dasin Hausa Dam originally planned to complement Cameroon's Lagdo Dam reflects a deeper failure of governance and transboundary coordination. Rather than the mere absence or presence of physical structures, it is the lack of integrated, science-based, and adaptive water governance that perpetuates flood risk in both regions.

Moreover, large-scale infrastructure projects often carry accompanying side effects, including habitat loss, forced displacement, altered river dynamics, and long-term socio-economic inequalities. While intended to enhance productivity and resilience, such projects can inadvertently amplify exposure to environmental hazards and erode the very systems they seek to protect.

These case studies demonstrate that effective flood mitigation requires more than engineering ingenuity; it demands institutional cooperation, long-term planning, and ecological foresight. The lessons from Pakistan's Indus Basin and Nigeria's Benue Basin converge on the same imperative: to move beyond reactive infrastructure planning toward basin-wide, ecosystem-based management that harmonizes human development with natural hydrology. Sustainable solutions must therefore prioritize transboundary collaboration, equitable resource management, and the restoration of ecological buffers such as wetlands, mangroves, and riparian vegetation. Only through such integrated approaches can developing nations reduce vulnerability, safeguard livelihoods, and transform infrastructure from a source of risk into a foundation for resilience.

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