

HYDRO-METEOROLOGICAL DISASTERS IN SOUTH ASIA (2018–2023): A COMPARATIVE REVIEW OF THE 2021 UTTARAKHAND FLOODS AND THE 2020 CYCLONE AMPHAN

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ABSTRACT

The present review paper provides a comparative holistic analysis of two of the biggest hydro-meteorological catastrophes that hit South Asia between 2020–2021—Amphan Cyclone (2020) and the Uttarakhand Floods (2021). These catastrophes are symptomatic of the emerging trend of climatic hazards in the region and indicate the imperativeness of enhanced resilience and adaptive capacity. The main aim of the present study is to analyse the causative factors, environmental and socio-economic effects, response strategies, and long-term effects with regard to such disaster events.

Analysis relied on secondary information sourced from reliable websites such as Emergency Events Database (EM-DAT), India National Disaster Management Authority (NDMA), World Bank publications, and peer-reviewed scholarly articles. Comparative case study design involving qualitative and quantitative data was utilized in examining overlapping vulnerabilities and unique response effects.

The research shows Cyclone Amphan, the most powerful storm to ever strike the Bay of Bengal, demolished structures and brought over \$13 billion in economic damage, striking millions on the coasts of India and Bangladesh. The Uttarakhand Floods, however, caused by a probable glacial lake outburst flood (GLOF) or landslide, caused catastrophic casualty and infrastructure damage to hydroelectric projects, revealing the vulnerability of the Himalayan environment. The two catastrophes were triggered by unplanned urban development, deforestation, and environmental mismanagement.

It believes that while Amphan showed the success of early warnings and mass evacuations, the Uttarakhand Flood revealed serious gaps in preparation and vigilance in hill states. It calls for scaling up climate adaptation policy, real-time hydrological monitoring, and disaster management systems at the community level. It calls for the need to converge climate science, sustainable development planning, and technology-driven early warning systems in a way that South Asian hydro-meteorological hazards are kept at bay in the future.

1. INTRODUCTION

Picture South Asia—a sprawling mosaic of towering mountains, fertile river deltas, and crowded coastal cities, that are home to nearly two billion people all of whom depend on the monsoon’s rhythm to grow rice, raise families, and power economies.¹¹ It’s a region of breathtaking beauty, but also one perched on a knife’s edge when it comes to weather gone wild. Between 2018 and 2023, the storms, floods, and cyclones came faster and hit harder, leaving little doubt that climate change is no longer a distant warning but a present-day reality.¹²

Official picture says that across Asia, eight out of every ten weather disasters in recent years were either floods or storms. In 2023 alone, the continent got 79 such events—more than anywhere else on Earth—killing around 2,000 people and uprooting millions more.¹³ Warmer oceans are brewing monster cyclones.¹⁴ Erratic rains are turning predictable monsoons into flash-flood lotteries.¹⁵ And up in the Himalayas, glaciers are have shrunk so fast that entire lakes of meltwater now are on the brink of collapse.¹⁶

This turbulent stretch is bookend by two disasters that stretch and demand our attention. Cyclone Amphan tore through the Bay of Bengal in the thick of the pandemic, slamming into the low-lying coasts of West Bengal and Bangladesh with winds that howled at 185 km/h.¹⁷ Nine months later, a chunk of mountain the size of a small city broke loose above Uttarakhand’s Chamoli district, unleashing a wall of water and debris that erased roads, bridges, and two hydropower dams in minutes.¹⁸

Though separated by geography and timing, the common thread running through the spate of such disasters a warming planet pushing natural systems past their breaking points.¹⁹ They also diverge in critical ways like how much warning we had? how well we responded, and what kind of long-term healing will be needed in the future. By comparing them side by side, we hope to spotlight practical pathways toward a tougher and more adaptable South Asia.²⁰

2. LITERATURE REVIEW: -

Scholars have been sounding the alarm on South Asia’s weather woes for years, and the data keeps getting louder. Warmer waters in the Indian Ocean is like rocket fuel for cyclones; the 2007 Cyclone Sidr in Bangladesh killed around 3,000 showing just how deadly poor coastal defenses can be.²¹ Fast-forward to 2013, and Cyclone Phailin hit the same region with even greater force—yet far fewer lives were lost, thanks to better forecasts and mass evacuations.²² The takeaway? Technology and planning can save lives, but they can’t erase the billions wiped out in ruined crops and shattered infrastructure.²³

Shift the frame upwards to the Himalayas, and a different kind of fragility comes into view. Glaciers here retreat at breakneck speed, leaving behind unstable in their wake which can burst without warning.²⁴ The research into GLOFs reads like a catastrophic disaster movie in slow-motion disaster scripts—add in deforestation and poorly sited dams, and you have a recipe for catastrophe.²⁵

Big cities were not spared either. Mumbai and Karachi often drown under monsoon rains because drainage systems are never kept pace with concrete sprawl.²⁶ The IPCC warns that heavy downpours will only get heavier, turning coastal rivers into overflowing bathtubs.²⁷ Across the board, researchers agree on one painful gap: scientific warnings exist, but they rarely translate into policy fast enough—or fairly enough—to protect the poorest farmers, fishers, and mountain villagers who bear the brunt.²⁸

This rich body of work gives us a sturdy scaffold for comparing Amphan and Uttarakhand. It reminds us that while nature pulls the trigger, human decisions—where we build, what we cut down, how we plan—load the gun.²⁹

3. METHODOLOGY

We approached this review like detectives piecing together two crime scenes. A comparative case study let us zoom in on each disaster while keeping an eye on overlapping clues.³⁰ All our evidence came from secondary sources—no new fieldwork, but plenty of rigorous cross-checking.

Numbers came first: EM-DAT supplied death tolls, economic losses, and counts of people displaced³¹ India's NDMA filled in response timelines and rescue stats.³² Satellite photos from NASA and ISRO traced flood paths and landslide scars.³³ For context on climate drivers, we tapped global datasets from the World Meteorological Organization and IPCC reports.³⁴

On the quantitative side, we simple statistics such as average, sum, percentage to outline trends in the 2018–2023 window.³⁵ Qualitatively, we looked official reports and journal articles for themes: How fast the government reaction was? How prepared local communities were? Where and what policies fall short?³⁶

Our comparison revolved on three axes:

Predictability (days of cyclone warnings vs. minutes for a mountain collapse)³⁷

Vulnerability (crowded coasts vs. remote valleys)³⁸

Adaptation (evacuation success vs. glacial monitoring gaps)³⁹

We're are transparent about limitations. The Himalayan villages frequently go under-counted in most of the global databases.⁴⁰ It is tough to pin any single flood squarely on climate change is tricky when local mismanagement plays a role.⁴¹ To counter these blind spots, we triangulated with multiple sources and relied on peer-reviewed studies for nuance.⁴²

4. CASE STUDY ANALYSIS

4.1 THE 2021 UTTARAKHAND FLOODS, INDIA

February 7, 2021, started like any winter morning in Chamoli—crisp air, prayer flags fluttering above the Rishiganga River. Then, at 10:21 a.m., a 27-million-cubic-meter wedge of rock and ice peeled off Ronti Peak, 6,063 meters up.⁴³ What followed was less a flood than a moving mountain: a 30-meter-high wave of mud, boulders, and water that swallowed everything in its path.⁴⁴

Two hydropower projects—the 13.2 MW Rishiganga plant and the half-built Tapovan-Vishnugad tunnel—were obliterated within minutes.⁴⁵ Bridges vanished. Roads turned into rivers. Villages like Raini, perched on steep slopes, lost homes and loved ones. By the time the debris settled, 204 bodies had been recovered; dozens

more were never found.⁴⁶ Damage estimates climbed into the hundreds of millions of dollars, but the true cost was measured in shattered livelihoods and a tourism season that never recovered.⁴⁷

Early theories pointed to a glacial lake bursting, but scientists later confirmed a massive rockslide, supercharged by permafrost thaw and recent heavy snow.⁴⁸ Climate change didn't cause the avalanche, yet it stacked the deck—thinner ice, wetter slopes, more weight on fragile cliffs.⁴⁹

Rescue teams swung into action fast. Army helicopters airlifted stranded workers from the Tapovan tunnel.⁵⁰ The Indo-Tibetan Border Police navigated treacherous terrain to reach cut-off hamlets. Over 100 lives were saved in the first 48 hours.⁵¹ Still, the speed of the disaster left little room for prevention. No sirens, no evacuation drills—just a wall of water and a frantic race against time.⁵²

Long-term fallout lingers. Rivers still choke on sediment, raising the risk of future flash floods.⁵³ Locals speak of quieter winters, fewer tourists, and a gnawing fear every time clouds gather over the peaks.⁵⁴



fig. 4.1 satellite before-and-after imagery showing the scar left on ronti peak and the flood's muddy fingerprint down the valley.⁵⁵

4.2 CYCLONE AMPHAN, 2020

Amphan announced itself early. By May 16, meteorologists were tracking a depression in the Bay of Bengal.⁵⁶ Within 48 hours it exploded into a super cyclone—winds topping 185 km/h, a storm surge taller than a two-story building.⁵⁷ On May 20, it made landfall between India's Sagar Island and Bangladesh's Hatiya, right as COVID-19 lockdowns kept millions indoors.⁵⁸

The destruction was biblical. In West Bengal, entire villages vanished under saltwater.⁵⁹ Kolkata, a city of 15 million, went dark for days—power pylons twisted like straw, embankments breached, streets turned into

canals.⁶⁰ Across the border, the Sundarbans lost thousands of mangrove trees, nature's speed bumps against future storms.⁶¹ Official death tolls hovered between 128 and 133, but the economic ledger was staggering: \$13–15 billion in damages, 0.2 million hectares of paddy and shrimp ponds ruined, millions homeless.⁶²

What saved thousands of lives was preparation. India's Meteorological Department issued pinpoint forecasts.⁶³ Bangladesh's cyclone shelters—built after the deadly 1991 storm—opened despite pandemic fears.⁶⁴ Over three million people were moved to safety in 48 hours, an evacuation on a scale few countries could match.⁶⁵ Door-to-door teams, bullhorns, and WhatsApp groups spread the word. When the storm passed, the same networks delivered rice, tarps, and medicine.⁶⁶

Yet recovery drags. Saltwater has poisoned farmland for years to come.⁶⁷ Mangrove gaps leave coasts naked to the next surge. And in the shadow of COVID, rebuilding feels like running uphill.⁶⁸

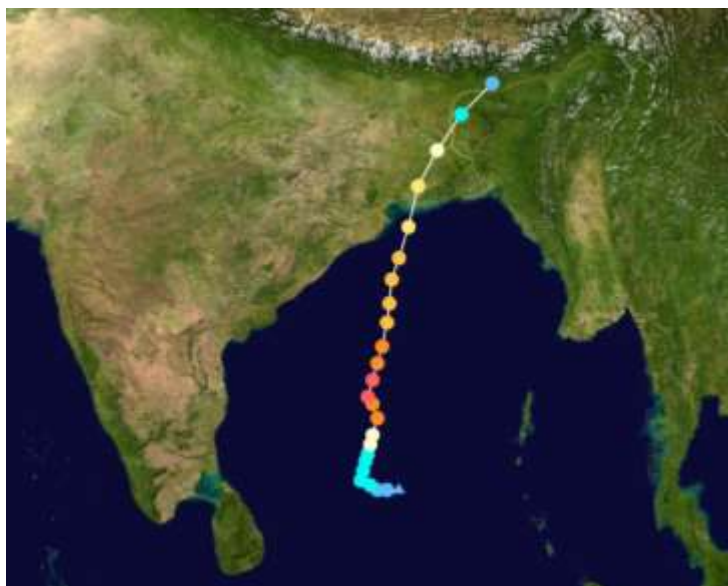


fig. 4.2 the cyclone's tightly coiled path, tracked hour by hour from satellite, ending in a red slash across the delta.⁶⁹

5. DISCUSSION AND COMPARATIVE INSIGHTS

Put Amphan and Uttarakhand side by side, and the contrasts leap out—yet so do the common threads.

Warning windows tell the story best. Amphan gave officials five full days to sound alarms and move people.⁷⁰ Uttarakhand offered maybe five minutes between rumble and ruin.⁷¹ One disaster rewarded investment in radars and shelters; the other exposed how little we've done to watch the high peaks.⁷²

Death tolls reflect that gap. Amphan killed around 130 despite hitting 13 million people.⁷³ Uttarakhand took over 200 in a sparsely populated valley.⁷⁴ Lives saved on the coast; lives lost in the mountains.

Economic pain cuts deeper on flat land. Amphan's \$15 billion bill dwarfed Uttarakhand's, because coasts pack more homes, factories, and fields into every square kilometer.⁷⁵ But per-person impact? Mountain communities lost their only road, their only power plant, their only tourist season.⁷⁶

Human fingerprints are everywhere. Dams built too close to unstable slopes in Chamoli.⁷⁷ Embankments too low, mangroves too thin along the Bengal coast.⁷⁸ Deforestation in both places left soil naked to erosion.⁷⁹ Weak zoning laws let people settle in harm's way.⁸⁰

Coordination varied. India and Bangladesh shared cyclone data seamlessly—an under-celebrated diplomatic win.⁸¹ In Uttarakhand, state and central agencies scrambled to align, slowing rescues in the critical first hours.⁸²

Marginalized voices were loudest in the aftermath. Fisherfolk in the Sundarbans, porters in Raini village—people with the least cushion absorbed the hardest blows.⁸³

Taken together, these disasters scream for a new playbook: one that treats early warning as a human right, infrastructure as climate armor, and local knowledge as the first line of defense.⁸⁴

6. CONCLUSION AND RECOMMENDATIONS

South Asia's weather disasters are no longer rare shocks—they're the new normal, and they're getting meaner.⁸⁵ Amphan and Uttarakhand are wake-up calls wrapped in tragedy. One proved we can save lives when we act fast and together.⁸⁶ The other showed how blindsided we remain when the threat comes from above.⁸⁷

To turn the tide, we offer five grounded, do-able steps:

Build smarter, not just bigger. Hydropower dams need setback zones from glaciers. Coastal towns need living shorelines—mangroves, not just concrete.⁸⁸

Watch the lakes that watch us. Satellites and AI can flag risky glacial lakes in real time; pair that with ground sensors and village alert networks.⁸⁹

Share early, share often. Expand the SAARC disaster data platform so every country sees the same radar screen, the same satellite feed.⁹⁰

Drill down to the doorstep. Every riverside hamlet, every coastal panchayat should run mock evacuations twice a year—kids, elders, livestock included.⁹¹

Bake climate into every budget. Road projects, city master plans, farm subsidies—all must pass a “future flood” stress test.⁹²

Finally, let’s keep studying the aftermath. Who rebuilds fastest? Whose fields stay salty longest? Whose daughters go back to school first? Only by tracking recovery through the lens of gender, caste, and income can we build a South Asia that doesn’t just survive disasters—but emerges fairer and stronger.⁹³

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