Journal of Agroforestry and Environment

Volume 19, Issue 2, 2026

Journal DOI: https://doi.org/10.55706/jae

Journal homepage: www.jagroforenviron.com

Emergency Response and Management of Pandemic Disasters and Their Environmental Dimensions: A Review of Lessons from COVID-19 in Bangladesh

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Received: 12/08/2026

Accepted: 10/10/2026

Available online: 12/10/2026

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Abstract: Pandemics are disasters whose causes and consequences are both rooted in the environment, yet emergency management and environmental management are usually reviewed apart. This narrative review synthesizes 74 documents published between 2008 and 2026, comprising peer-reviewed studies, reports of intergovernmental and national agencies, and selected news and NGO records, to examine the emergency response to COVID-19 in Bangladesh, with the European Union as a comparator, and to connect that response to its environmental dimensions. Bangladesh confirmed its first cases on 8 March 2020 and by mid-2025 had recorded more than 2.05 million cases and about 29,500 deaths. The early response was weakened by late and poorly coordinated decisions, limited testing, about 0.7 intensive-care beds per 100,000 people, shortages of protective equipment and weak risk communication, although two-dose vaccination coverage later reached about 70%. Environmentally, nitrogen dioxide over Dhaka fell by roughly two-thirds during the 2020 lockdown, but the gain was temporary, whereas at least 14,500 tonnes of health-care waste were generated nationally in April 2020 alone and only about 7% of COVID-19-related waste was properly managed. Cyclone Amphan and the 2020 monsoon floods struck during the lockdown and created compound emergencies, while disrupted food supply chains and tourism deepened livelihood losses. The evidence supports a One Health-based, all-hazards approach: preventing spillover through ecosystem protection, building low-waste and climate-resilient health facilities, institutionalizing wastewater and zoonotic surveillance, planning for concurrent hazards and protecting food systems. The amended International Health Regulations and the 2025 WHO Pandemic Agreement provide a timely framework for this integration.

Keywords: Pandemic preparedness; One Health; Medical waste; Compound hazards; Bangladesh.

INTRODUCTION

Emergency planning has long moved between two logics: an "all-hazards" approach built on what disasters have in common, and scenario-specific plans tailored to a single cause. Public health emergency management draws on both, combining the knowledge, techniques and organizing principles needed to manage complex health events (Burkle 2019). Routine health care, however, is organized around encounters between one clinician and one patient (Graffunder and Sakurada 2016). A pandemic reverses that logic. When a whole population is at risk, the unit of management becomes the community, and decisions must weigh the social and structural determinants of health alongside clinical need, an approach described as population-based management (Stoto 2014; Burkle 2019).

International disaster policy now treats epidemics and pandemics explicitly as disasters. The Sendai Framework for Disaster Risk Reduction 2015–2030 includes biological hazards within its scope (UNDRR 2015), and the WHO Health Emergency and Disaster Risk Management Framework calls for health risks to be managed across prevention, preparedness, response and recovery instead of through response alone (WHO 2019; Djalante et al. 2020). The crises that health systems face are also increasingly entangled. Emerging zoonoses, climate extremes, biodiversity loss, rapid unplanned urbanization, displacement and antimicrobial resistance interact in ways that exceed the capacity of conventional, response-centered disaster management and demand cooperation across disciplines and sectors (Burkle 2019; Foddai et al. 2020).

The environment sits at both ends of this problem. Upstream, about 60% of known human infectious diseases and 75% of emerging ones are zoonotic (UNEP and ILRI 2020), and most emerging infectious disease events of recent decades originated in wildlife (Jones et al. 2008). Land-use change, wildlife exploitation, intensified livestock production and climate change bring people, domestic animals and wildlife hosts into closer contact (Gibb et al. 2020; IPBES 2020; Carlson et al. 2022). Downstream, the response to a pandemic leaves an environmental footprint of its own, most visibly in health-care and plastic waste (Peng et al. 2021; WHO 2022), and it unfolds alongside floods, cyclones and other hazards that do not pause for an outbreak (Phillips et al. 2020). The One Health approach, which seeks to balance and optimize the health of people, animals and ecosystems together, offers a way to hold these strands in one frame (OHHLEP 2022).

Coronavirus disease 2019 (COVID-19) tested these ideas at global scale. First identified in Wuhan, China, in December 2019, it was declared a public health emergency of international concern on 30 January 2020 (Sohrabi et al. 2020) and characterized as a pandemic on 11 March 2020 (Goniewicz et al. 2020); the emergency declaration was lifted only on 5 May 2023 (WHO 2023a). WHO estimates that 14.8 million excess deaths were associated with the pandemic in 2020 and 2021 alone (Msemburi et al. 2023). Bangladesh, one of the most densely populated and climate-vulnerable countries in the world, confirmed its first cases on 8 March 2020 (Islam et al. 2020) and by mid-2025 had recorded more than 2.05 million confirmed cases and about 29,500 deaths (DGHS 2025). Its health-system response has been examined in several studies (Al-Zaman 2020; Anwar et al. 2020; Islam et al. 2020; Shammi et al. 2021), but the environmental drivers and consequences of the emergency have mostly been discussed separately from its management.

This review therefore has three objectives: (i) to describe the emergency response and management system applied to pandemic disasters, focusing on Bangladesh's response to COVID-19 with the European Union as a comparator; (ii) to examine the environmental drivers and consequences of the pandemic and of the measures taken against it; and (iii) to draw lessons for environmentally integrated pandemic preparedness in Bangladesh and comparable settings.

MATERIALS AND METHODS

Review design

A narrative (integrative) review design was adopted because the questions span public health, disaster management and environmental science and rest on heterogeneous evidence that cannot be pooled statistically.

Search strategy and sources

The literature was assembled in two stages. The first stage covered the emergency response to COVID-19 and included documents issued between 1 January 2020 and 31 January 2022 by national governments and ministries of health, WHO and United Nations country teams, together with journal articles and newspaper reports. The second stage, completed in October 2026, updated the evidence to mid-2026 and extended it to the environmental dimensions of pandemics. Searches were run in PubMed/PubMed Central, Google Scholar and publisher platforms and on the websites of WHO, ReliefWeb and the Directorate General of Health Services. Search terms combined the hazard (COVID-19, SARS-CoV-2, pandemic, zoonosis), the management function (emergency response, preparedness, disaster management, lockdown, vaccination) and the environmental dimension (One Health, medical waste, plastic, air quality, wastewater, cyclone, flood, food system, tourism), with and without "Bangladesh" and "European Union".

Eligibility and selection

Documents were retained if they (i) reported primary data, official statistics or an authoritative synthesis on pandemic emergency management or on an environmental driver or consequence of a pandemic; (ii) concerned Bangladesh, the European Union or the global level; and (iii) were available in English as full text. Where an institution had issued several versions of a document, the most recent was used. Newspaper and NGO reports were used only to document dated events or survey results that were not available in the scientific literature. Opinion pieces without

DOI: https://doi.org/10.55706/jae1933

data and duplicate reports were excluded. In total, 74 documents were included: 43 journal articles and scholarly papers, 22 reports and official documents of governments and intergovernmental bodies, and 9 news and NGO records (Figure 1; Table 1).

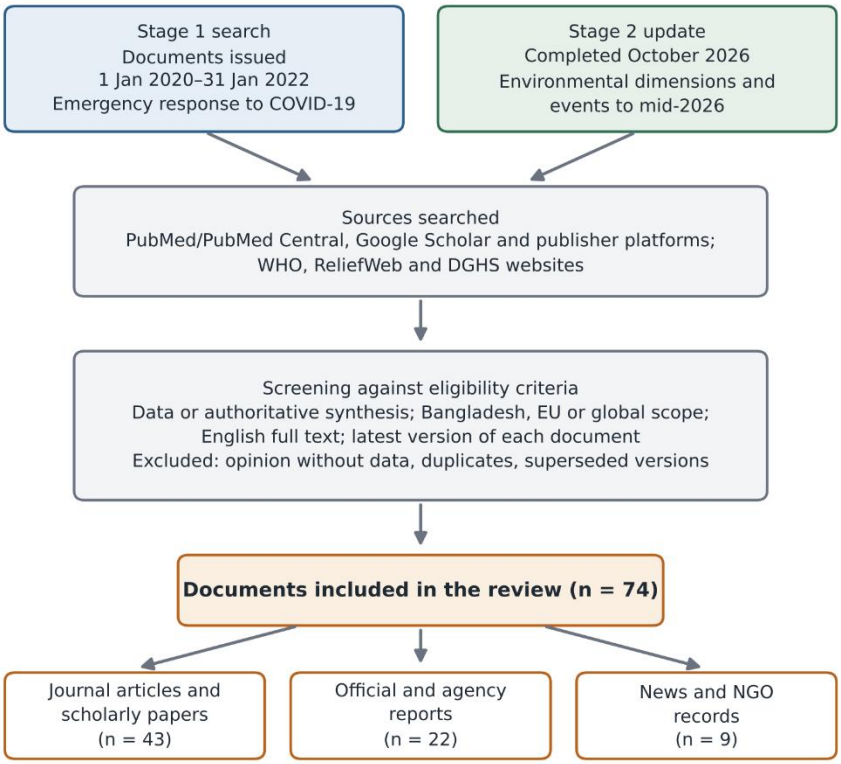

Figure 1. Identification and selection of the documents reviewed

Synthesis

Findings were extracted into a matrix and grouped under themes derived from the disaster management cycle (prevention, preparedness, response and recovery) and from the three domains of One Health (human, animal and environmental health). Because the review is narrative, no formal quality appraisal or meta-analysis was undertaken. Figures are reported as published and should be read with the dates and definitions of the original sources in mind.

Table 1. Themes of the review and number of documents included under each

Theme	Scope	Documents (n)
Concepts and frameworks	Emergency and disaster risk management; population-based management	7
Global emergence and course of COVID-19	Early spread, declaration and end of the emergency, excess mortality	7
Environmental origins of pandemic risk	Zoonotic spillover, land-use and climate change, One Health, Nipah virus	11
Emergency response in Bangladesh	Governance, health-system capacity, risk communication, therapies, vaccination	15
Environmental consequences	Health-care and plastic waste, air quality, wastewater surveillance, ecosystems	12
Compound hazards	Cyclones, floods and climate-sensitive disease during and after the pandemic	5
Food systems, livelihoods and tourism	Agriculture, supply chains, poverty, social effects, tourism	10
European Union	Crisis coordination and environmentally conditioned recovery	2
Global governance, 2022–2026	International Health Regulations, Pandemic Agreement, One Health Joint Plan of Action	5
Total		**74**

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RESULTS AND DISCUSSION

Global emergence and course of COVID-19

COVID-19 is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), first identified in Wuhan in late December 2019. By 20 January 2020, exported cases had been confirmed in Thailand, Japan and South Korea (Sohrabi et al. 2020). In Europe, the first cases were reported from France on 24 January (Lescure et al. 2020), and transmission from a contact without symptoms was documented in Germany within days (Rothe et al. 2020), an early signal that symptom-based screening would not contain the virus. Modeling of air-travel flows had already identified the main importation routes into Europe (Pullano et al. 2020). Repeated changes in the Chinese case definition made the true extent of spread uncertain, and as cases rose several European countries narrowed testing to symptomatic or severe cases (Johnson et al. 2020). Northern Italy reported a sharp increase in cases at the end of February 2020, and WHO characterized the outbreak as a pandemic on 11 March 2020 (Goniewicz et al. 2020), three days after Bangladesh confirmed its first cases (Figure 2).

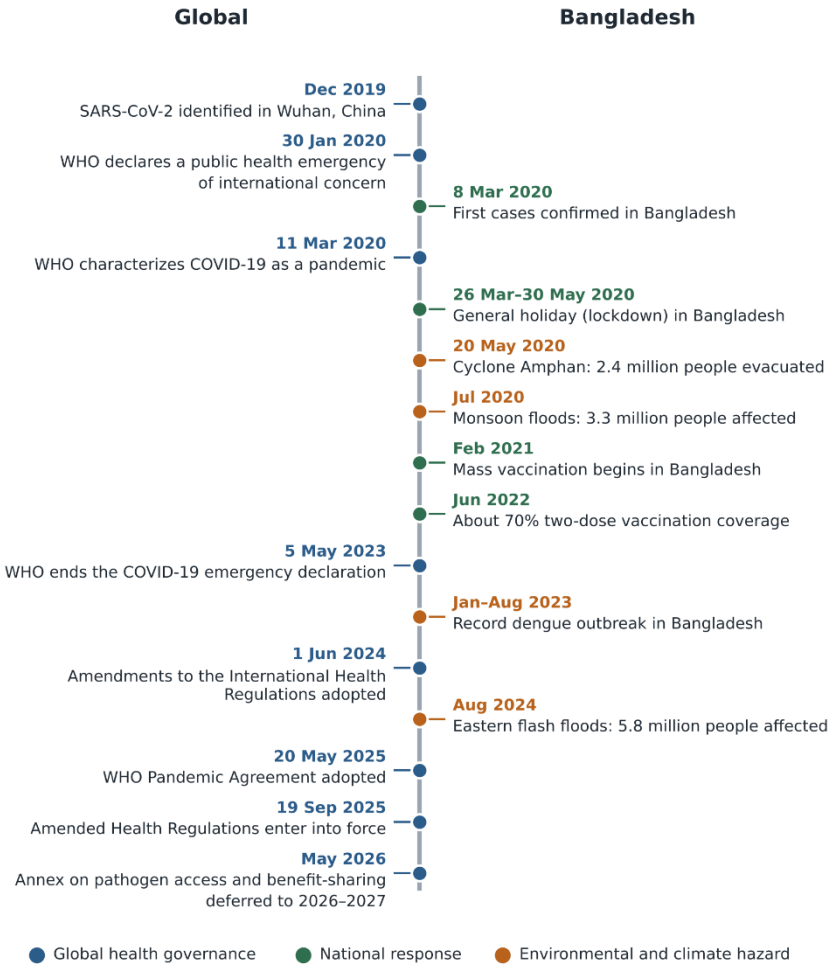

Figure 2. Timeline of the COVID-19 emergency, concurrent environmental hazards in Bangladesh and subsequent global governance milestones, 2019–2026

The acute phase ended formally on 5 May 2023, when the WHO Director-General determined that COVID-19 was "an established and ongoing health issue" that no longer constituted a public health emergency of international concern (WHO 2023a). The cost by then was far larger than reported deaths indicate, as the estimate of 14.8 million excess deaths in the first two years shows (Msemburi et al. 2023). The lesson for emergency management is that the response phase of a pandemic lasts years, not weeks, so plans built around a short surge are inadequate.

Environmental origins of pandemic risk

Pandemic risk is produced largely in the environment. In a global analysis of emerging infectious disease events between 1940 and 2004, 60.3% were zoonoses and 71.8% of those originated in wildlife (Jones et al. 2008). Where natural habitats are converted to farmland and settlements, the wildlife species that persist are disproportionately those that host pathogens shared with humans (Gibb et al. 2020). Climate change adds to this pressure. As species shift their ranges, new encounters among mammals are projected to create thousands of opportunities for cross-species viral transmission, concentrated in densely populated parts of Asia and Africa (Carlson et al. 2022), and 58% of known human infectious diseases have at some point been aggravated by climatic hazards (Mora et al. 2022). IPBES (2020) concluded that the human activities that drive climate change and biodiversity loss also drive pandemic risk, and

DOI: https://doi.org/10.55706/jae1933

that escaping an "era of pandemics" requires a shift from reaction to prevention.

Bangladesh illustrates these links directly. Nipah virus, carried by *Pteropus* fruit bats, has spilled over into people almost every year since 2001, mainly through raw date palm sap contaminated by bats; 347 cases with a case fatality rate of 71.7% had been reported by August 2025 (Luby et al. 2009; WHO 2025c). Dengue shows the climatic side of the same problem. Between January and early August 2023 the country recorded 69,483 laboratory-confirmed cases and 327 deaths across all 64 districts, the highest figures for that period since 2000, which WHO linked to unusual rainfall combined with high temperature and humidity (WHO 2023b). Preventing such events at source is far cheaper than responding to them: the annual cost of primary prevention through reduced deforestation, regulation of wildlife trade and better surveillance has been estimated at a small fraction of the losses that emerging viral zoonoses cause each year (Bernstein et al. 2022). Bangladesh adopted a national One Health strategic framework and action plan for 2017–2021 (Government of Bangladesh 2017). Even so, the documents reviewed here give little indication that environmental or animal-health agencies had a defined role in the COVID-19 response.

Emergency response in Bangladesh: Governance and coordination

Bangladesh issued a National Preparedness and Response Plan for COVID-19 on 16 March 2020, with the aims of preventing entry of the disease, limiting local transmission and maintaining essential health services (Government of Bangladesh 2020). The measures that followed resembled those used elsewhere (Table 2). A national committee headed by the Minister for Health was formed; public events, including national celebrations, were cancelled; educational institutions, offices and public transport were closed; domestic and international flights were suspended; and the armed forces and police were deployed to enforce physical distancing. Subsidized rice sales, an expanded social safety net and stimulus packages for industry, small enterprises, agriculture and health workers accompanied the restrictions (Islam et al. 2020). The government eventually announced 19 packages worth about USD 12.13 billion (Al-Zaman 2020).

Implementation was weaker than design. In the two weeks after the first cases were confirmed, more than 630,000 overseas workers entered the country without effective screening. Only a handful of thermal scanners were available at the international airports, and neither sampling nor disinfection was carried out at entry points (Al-Zaman 2020; Islam et al. 2020). The restriction on movement was announced as a "general holiday" and was declared without first restricting transport; more than 12 million people left Dhaka for their home districts, which accelerated community transmission (Al-Zaman 2020). Garment and other factory workers then travelled back to Dhaka, Narayanganj, Gazipur and Chattogram when the first closure ended and returned home again when it was extended, and shops and shopping malls were allowed to reopen before the Eid festival even though many owners were reluctant (Islam et al. 2020). Two laws that could have provided a legal basis for stricter control, the Disaster Management Act 2012 and the Infectious Diseases (Prevention, Control and Elimination) Act 2018, were not applied effectively (Al-Zaman 2020).

Governance failures compounded these problems. Coordination among the Ministry of Health and Family Welfare, the Directorate General of Health Services and the testing laboratories was poor; 218 incidents of corruption in relief distribution were reported in the media between 10 March and 15 June 2020; and cases of procurement fraud and forged test certificates came to light (Al-Zaman 2020; Islam et al. 2020). Early assessments had warned that mitigation would be extremely difficult given the country's population density and limited resources and had recommended decentralized measures such as mobile sanitization facilities and temporary quarantine and treatment sites (Anwar et al. 2020). Scenario analysis similarly showed that a complete withdrawal of restrictions would accelerate infections and deaths (Shammi et al. 2021). By 11 August 2020, 263,503 cases and 3,471 deaths had been reported from all 64 districts, concentrated in Dhaka, Narayanganj, Gazipur and Chattogram, where population density and industry are highest (Islam et al. 2020).

Table 2. Main emergency response measures against COVID-19 in Bangladesh and the gaps observed

Function	Measure	Gap observed	Source
Planning and entry screening	National preparedness and response plan issued on 16 March 2020; thermal screening at airports	More than 630,000 arrivals in two weeks without effective screening; no sampling or disinfection at entry points	Government of Bangladesh (2020); Al-Zaman (2020); Islam et al. (2020)
Containment	General holiday from 26 March to 30 May 2020; closure of offices, schools and transport; suspension of flights; deployment of police and armed forces	Holiday declared before transport was restricted; more than 12 million people left Dhaka; repeated movement of factory workers	Al-Zaman (2020); Islam et al. (2020); Islam et al. (2021)
Health-system surge	Emergency recruitment of about 2,000 doctors and 6,000 nurses; expansion of RT-PCR testing	56 testing laboratories by mid-2020; low testing rate; shortage and poor quality of protective equipment	Kamol (2020); Al-Zaman (2020)
Social protection and economic relief	Subsidized rice, wider safety nets, 19 stimulus packages worth about USD 12.13 billion	218 reported incidents of relief-related corruption between 10 March and 15 June 2020	Al-Zaman (2020); Islam et al. (2020)

Function	Measure	Gap observed	Source
Risk communication	Official statistics and guidance; legal action against rumor-spreading	About 200 online rumors between March and July 2020; restrictions that could also discourage legitimate health communication	Al-Zaman (2020)
Vaccination	Mass vaccination from February 2021; about 70% two-dose coverage by late June 2022	38.84% of adults surveyed before the rollout were unwilling or undecided	Mahmud et al. (2021); Dhaka Tribune (2022)
Environmental management	Medical Waste (Management and Processing) Rules 2008 in force	Only 6.6% of COVID-19-related waste properly managed in mid-2020	Rahman et al. (2020); Dhaka Tribune (2020)

Health-system capacity and the frontline workforce

The health system entered the pandemic with very little surge capacity (Table 3). Bangladesh had about 0.87 hospital beds per 1,000 people, 0.72 intensive-care beds and 1.1 ventilators per 100,000 people, and between three and five physicians per 10,000 people depending on the source (Al-Zaman 2020; Islam et al. 2020). Facilities were concentrated in cities, leaving rural areas underserved (Al-Zaman 2020), and early accounts of the response describe limited diagnostic capacity (Monjur and Hassan 2020). By mid-2020 only 56 laboratories were testing, private tests cost USD 50–60, the testing rate was among the lowest in South Asia, and the introduction of a fee in public laboratories reduced daily testing further (Al-Zaman 2020). Low testing left many infections undetected: 20.46% of tests were positive by August 2020, and 1,010 people were reported to have died with COVID-19 symptoms but without a diagnosis between March and May 2020 (Al-Zaman 2020; Islam et al. 2020).

Access to care deteriorated as cases rose. Many private facilities, which normally provide about three-quarters of care, were unwilling to treat suspected cases, and about 79% of patients were managed at home (Al-Zaman 2020). Health workers were issued too little and substandard protective equipment; many doctors were infected and some died (Al-Zaman 2020). The government responded by recruiting about 2,000 doctors and 6,000 nurses on an emergency basis (Kamol 2020).

The age profile of cases added an occupational dimension. About 68% of confirmed cases were in people aged 21–50 years and only 21% in those older than 50, a pattern similar to that in India but unlike that in Italy or the United States; working-age adults who could not stay at home carried much of the infection burden (Islam et al. 2020). The recovery rate in August 2020 (57.67%) was lower than in neighboring countries, which the same authors attributed partly to limited health services and to the double burden of communicable and non-communicable disease.

Table 3. Selected indicators of health-system capacity and performance in Bangladesh during the first wave of COVID-19

Indicator	Value	Source
Population density	1,115 people km^{-2}	Al-Zaman (2020)
Population below the poverty line	21.8%	Al-Zaman (2020)
Physicians	3.05–5.3 per 10,000 people	Al-Zaman (2020); Islam et al. (2020)
Nurses	1.07–3 per 10,000 people	Al-Zaman (2020); Islam et al. (2020)
Hospital beds	0.87 per 1,000 people	Islam et al. (2020)
Intensive-care beds	0.72 per 100,000 people	Islam et al. (2020)
Ventilators	1.1 per 100,000 people	Islam et al. (2020)
Testing laboratories (mid-2020)	56	Al-Zaman (2020)
Cost of a private test	USD 50–60	Al-Zaman (2020)
Test positivity (to 11 August 2020)	20.46%	Islam et al. (2020)
Recovery rate (11 August 2020)	57.67%	Islam et al. (2020)
Patients treated at home	79%	Al-Zaman (2020)

Risk communication, public behavior and vaccine acceptance

Weak public health communication was the third fault line identified by Al-Zaman (2020), alongside governance and facilities. Uncertainty, a shortage of trusted sources and the growth of social media allowed about 200 COVID-19-related rumors to circulate online between March and July 2020. The authorities responded partly by detaining people accused of spreading rumors and by restricting public servants' social-media activity, steps that rights groups warned could also discourage legitimate health communication. A rapid BRAC survey early in the lockdown found gaps in knowledge of how to prevent infection alongside a steep loss of income (BRAC 2020), and a further study documented how the public perceived and responded to the lockdown (Rahman et al. 2021). Compliance was constrained as much by circumstances as by attitudes. For households that depend on daily wages and live in crowded housing, staying at home for weeks was not feasible, and lockdown models designed elsewhere could not simply be transferred (Anwar et al. 2020; Shammi et al. 2021).

The same factors shaped vaccine uptake. In an online survey of 605 adults conducted from 30 January to 6 February 2021, just before mass vaccination began, 61.16%

of respondents were willing to be vaccinated, but almost two-thirds of them preferred to wait. Among those who were unwilling or undecided, 78.52% were worried about side effects and 76.17% doubted efficacy. Willingness was higher among respondents with more education, urban residence, higher income, good knowledge of COVID-19 and previous experience of adult vaccination (Mahmud et al. 2021). Registration was slow at first, and the government lowered the age threshold from 55 to 40 years to widen eligibility (Mahmud et al. 2021). Sustained campaigns and the arrival of vaccines from several suppliers changed the picture: by late June 2022 about 129 million people had received a first dose and 119 million a second, roughly 70% two-dose coverage (Dhaka Tribune 2022). Mass vaccination was therefore the most successful element of the response, and it shows that hesitancy measured early in a campaign need not determine the final outcome when access is made easy.

Unproven therapies and diagnostics

The search for treatments early in the pandemic produced claims that outran the evidence. A case series from Dhaka reported that a combination of ivermectin and doxycycline was very effective in clearing the virus in mild and moderate cases (Alam et al. 2020), and hydroxychloroquine was also used. Subsequent randomized evidence did not support either: hydroxychloroquine did not reduce mortality in hospitalized patients (RECOVERY Collaborative Group 2020), and a Cochrane review found no reliable evidence that ivermectin prevents or treats COVID-19 (Popp et al. 2022). For emergency management the point is procedural. A crisis needs a rapid, transparent mechanism for evaluating and communicating evidence on therapies and diagnostics. Uncontrolled use of antimicrobials during outbreaks should also be avoided, because antimicrobial resistance is itself a One Health threat that links clinical practice to the environment (FAO et al. 2022).

Environmental consequences of the pandemic and its response

Health-care and plastic waste

Waste is the clearest environmental cost (Table 4). In April 2020 alone at least 14,500 tonnes of health-care waste were generated in Bangladesh, and COVID-19 added an average of 206 tonnes per day in Dhaka (Rahman et al. 2020). A BRAC survey in July–August 2020 estimated 248 tonnes of medical waste per day from health facilities, of which only 35 tonnes (14.1%) were properly managed, all in Dhaka, and a further 282 tonnes per day of masks, gloves and other protective items discarded by the public with household waste. Overall, only 6.6% of COVID-19-related waste was handled properly, and fewer than half of the 300 health workers interviewed knew of the national medical-waste rules (Dhaka Tribune 2020). The Medical Waste (Management and Processing) Rules date from 2008, yet no safe system had been built by the time the pandemic arrived, and about 40,000 informal waste collectors worked without adequate protection (Rahman et al. 2020).

The problem is global. Between March 2020 and November 2021 a joint United Nations initiative procured about 87,000 tonnes of personal protective equipment, most of which became waste. More than 140 million test kits generated 2,600 tonnes of mainly plastic waste and 731,000 liters of chemical waste, and the first 8 billion vaccine doses produced 144,000 tonnes of syringes, needles and safety boxes, while 30% of health-care facilities worldwide, and 60% in the least developed countries, could not manage even their existing waste (WHO 2022). An estimated 8.4 million tonnes of pandemic-associated plastic waste had been generated by August 2021, about 25,900 tonnes of which entered the oceans (Peng et al. 2021). Single-use plastics, open dumping and uncontrolled burning thus turned a health emergency into a pollution problem (Rume and Islam 2020; Zambrano-Monserrate et al. 2020).

Air quality and emissions

Restrictions on movement produced a short-lived improvement in air quality. Across Bangladesh, nitrogen dioxide (NO_2) fell by about 40% and sulfur dioxide (SO_2) by about 43% during the lockdown of 26 March to 30 May 2020, with the largest NO_2 decline, about 69%, over Dhaka; carbon monoxide fell only slightly (1.6–7.2%) and ozone rose by about 3% (Islam et al. 2021). Similar patterns were observed worldwide. Population-weighted NO_2 and fine particulate matter ($PM_{2.5}$) declined by about 60% and 31%, respectively, across 34 countries (Venter et al. 2020), and daily global CO_2 emissions in early April 2020 were about 17% below the 2019 mean (Le Quéré et al. 2020). These reductions disappeared as activity resumed. Their value lies in what they demonstrate: urban air pollution in Bangladesh responds quickly to lower traffic and industrial emissions, so cleaner air is achievable through policy and not only through crisis.

Wastewater and environmental surveillance

The environment also proved useful as a source of surveillance data. Sewage sampling across Dhaka from December 2019 to December 2021 detected SARS-CoV-2 at similar levels in neighborhoods of all income groups, although high-income areas, home to a quarter of the study population, accounted for 60.3% of reported clinical cases, and viral load in sewage rose one to two weeks before clinical cases did (Rogawski McQuade et al. 2023). Environmental surveillance therefore offers early warning and a more equitable picture of transmission where testing is scarce, a direct remedy for the diagnostic gaps described above.

Coastal ecosystems

Ecosystems responded to the absence of people. On the Cox's Bazar coast, beach morning glory (*Ipomoea pes-caprae*), a sand-binding creeper that had disappeared from the most visited beaches, recolonized them within weeks of the tourism shutdown (The Daily Star 2020). Reduced disturbance also made it easier to protect nesting sea turtles, although the loss of ecotourism income interrupted funding for conservation work (Islam 2020). The respite was temporary, but it gives a rare observed baseline for the carrying capacity of heavily used coastal sites.

DOI: https://doi.org/10.55706/jae1933

Table 4. Environmental dimensions of the COVID-19 emergency: evidence and implications for emergency management

Dimension	Evidence	Direction	Implication for emergency management
Zoonotic spillover	60.3% of emerging infectious disease events are zoonoses (Jones et al. 2008); 347 Nipah cases in Bangladesh since 2001, case fatality 71.7% (WHO 2025c)	Driver	Joint surveillance of wildlife, livestock and people; habitat protection as prevention
Climate	58% of human infectious diseases aggravated by climatic hazards (Mora et al. 2022); record dengue in 2023 (WHO 2023b)	Driver	Climate-informed early warning for outbreaks
Health-care waste	At least 14,500 tonnes in April 2020 (Rahman et al. 2020); 6.6% properly managed (Dhaka Tribune 2020)	Negative	Segregation, treatment capacity and protection of waste workers in emergency plans
Plastic pollution	8.4 million tonnes of pandemic-associated plastic waste, 25,900 tonnes to the ocean (Peng et al. 2021)	Negative	Reusable or lower-plastic protective equipment where safe; public disposal systems
Air quality	NO_2 −40% nationally and −69% in Dhaka; SO_2 −43%; ozone +3% (Islam et al. 2021)	Temporary positive	Evidence base for transport and industrial emission control
Carbon emissions	Daily global CO_2 −17% in early April 2020 (Le Quéré et al. 2020)	Temporary positive	Recovery spending tied to low-carbon investment
Wastewater	Viral load rose one to two weeks before clinical cases (Rogawski McQuade et al. 2023)	Opportunity	Routine environmental surveillance as early warning
Coastal ecosystems	Regrowth of dune vegetation; easier turtle protection but lost conservation funding (The Daily Star 2020; Islam 2020)	Mixed	Carrying-capacity limits and stable conservation finance
Concurrent hazards	2.4 million people evacuated for Cyclone Amphan (World Vision Bangladesh 2020); 3.3 million affected by floods (NAWG 2020)	Negative	Multi-hazard shelter, water and sanitation, and relief planning

Compound hazards: Cyclones, floods and climate-sensitive disease

Natural hazards did not wait for the pandemic to end. Cyclone Amphan made landfall on 20 May 2020, during the general holiday. More than 2.4 million people and about half a million cattle were moved to 14,636 shelters in 19 districts, about 200,000 ha of crops were destroyed, and coastal households already weakened by lost income faced a second shock (World Vision Bangladesh 2020). Opening that many shelters allowed evacuees to be spread out, and it shows that the cyclone preparedness system could adapt to a concurrent epidemic. Monsoon flooding followed. By late July 2020, 3.3 million people in 21 districts were affected, 93 had died and 81,179 latrines and 73,343 tube wells had been damaged, and the joint needs assessment found physical distancing and handwashing almost impossible to maintain among displaced people (NAWG 2020). Phillips et al. (2020) described this convergence of climate hazards and COVID-19 as compound risk, in which each hazard erodes the capacity to manage the other.

Compound events have continued since the acute phase of COVID-19. The 2023 dengue epidemic unfolded during an unusual monsoon (WHO 2023b), and the flash floods of August 2024 affected about 5.8 million people in eleven eastern districts and displaced more than 500,000 into 3,403 shelters, with damaged water and sanitation facilities raising the risk of water-borne disease (OCHA 2024). Planning for one hazard at a time is therefore no longer realistic. Shelter capacity, evacuation procedures, water, sanitation and hygiene services and relief logistics need to be designed for outbreaks and climate hazards occurring together.

Agriculture, food systems and livelihoods

Lockdown measures disrupted the food system at several points. Movement restrictions created local labor shortages for the harvest of winter (*rabi*) crops, including rice; demand for perishable, income-elastic foods such as fruit, vegetables, fish, milk, meat and eggs fell as incomes contracted and restaurants closed; supply chains for fertilizer, seed, machinery and agrochemicals were impeded; and lower sales revenue left farmers short of capital for the next season (Amjath-Babu et al. 2020). Dependence on imports adds exposure, since Bangladesh imports about 60% of its urea, more than 90% of key phosphate fertilizers and around six million tonnes of wheat a year (Amjath-Babu et al. 2020). Import consignments accumulated at Chattogram port because transport and labor were unavailable (Rahman and Illius 2020). Consumers faced the opposite price trend from farmers: over 2020 the retail price of rice rose by 17–48%, edible oil by 15–25% and lentils by 17–21%, increases attributed to supply disruption from the lockdown and the floods (The Financial Express 2020).

Livelihood losses were severe. A telephone survey of 12,000 households in early April 2020 found that income had fallen by 75% in urban slums and by 62% among rural respondents, that 22.9% of the population had newly fallen below the poverty line, and that households had cut food spending by 28% and 22%, respectively, mainly by reducing dietary diversity (PPRC and BIGD 2020). Lost daily wages put the food security of vulnerable groups at particular risk (Mottaleb et al. 2020). In the ready-made garment sector, the main source of export earnings, international orders were cancelled on a large scale (Islam et al. 2020). Social costs

followed. In a telephone survey covering 27 districts in April 2020, 4,249 women and 456 children reported domestic violence, 1,672 and 424 of them for the first time (Manusher Jonno Foundation 2020).

These findings matter for environmental management as well as for relief. Agriculture was the one sector that continued when almost all other economic activity was suspended (Islam et al. 2020). In our view this argues for treating diversified, locally rooted production, such as homestead gardens, agroforestry and short supply chains with local storage and market information, as part of pandemic preparedness, because such systems depend less on the long supply chains and migrant labor that movement restrictions interrupt. This proposition needs empirical testing in Bangladesh.

Tourism and nature-based destinations

Tourism depends on movement and was among the first sectors to stop. International arrivals worldwide fell by 74% in 2020, a loss of about one billion arrivals and USD 1.3 trillion in export revenue that put 100–120 million direct jobs at risk (UNWTO 2021). In Bangladesh, where tourism contributed about 4.4% of gross domestic product in 2018 and relies mainly on domestic travelers, destinations were closed from mid-March 2020, on-arrival visas and flights were suspended, and occupancy in the leading hotels of Dhaka and Chattogram fell from 80–90% to between 10% and 60% (Deb and Nafi 2020). The Bangladesh chapter of the Pacific Asia Travel Association estimated that about 309,500 jobs were at risk by June 2020 (The Business Standard 2020). Deb and Nafi (2020) concluded that the general stimulus packages were poorly matched to tourism and that a sector-specific recovery plan was required.

The environmental link runs in both directions. Bangladesh's principal destinations, among them Cox's Bazar, the Sundarbans and Saint Martin's Island, are ecologically sensitive, and the regrowth of dune vegetation during the closure showed how heavily visitor pressure weighs on them. Recovery planning that restores visitor numbers without limits would discard that information. Reopening is an opportunity to set carrying capacities, manage solid waste and plastics at destinations and direct recovery finance toward community-based and nature-based tourism, in line with calls to rethink the growth model of global tourism after the pandemic (Gössling et al. 2021).

Comparative experience: The European Union

The European Union (EU) offers a contrast in resources but not in the nature of the difficulties. The Council activated its integrated political crisis response arrangements on 28 January 2020, and in March EU leaders agreed common priorities covering public health, travel and transport, research, the economy and crisis management (Goniewicz et al. 2020). Member States nevertheless acted individually at first. Several closed their borders in mid-March, Poland on 15 March with a mandatory 14-day quarantine for returning citizens, and non-essential travel into the EU was restricted for an initial 30 days. Joint procurement of protective equipment and medical supplies through the civil protection mechanism, funding for vaccine and treatment research and financial support for wages and businesses followed (Goniewicz et al. 2020). The same authors concluded that the crisis exposed the limits of siloed decision-making and the need for population-based management and cooperation across disciplines. That conclusion also emerges from Bangladesh, despite a very large difference in health-system capacity.

Recovery in the EU was explicitly tied to environmental goals. The Recovery and Resilience Facility, adopted in February 2021, requires each national plan to devote at least 37% of its allocation to climate objectives and to respect the principle of doing no significant harm to the environment (European Parliament and Council of the European Union 2021). For Bangladesh the transferable element is the principle, not the scale: stimulus and recovery spending after a pandemic can be conditioned on environmental outcomes such as waste-management infrastructure, clean energy for health facilities and resilient food systems.

Lessons learned and recent developments

Table 5 and Figure 3 summarize the lessons across the disaster management cycle. Five stand out. First, prevention begins in the environment. Surveillance at the interface of people, animals and ecosystems, regulation of wildlife trade and live-animal markets and protection of habitats reduce the probability of spillover and cost little compared with response (IPBES 2020; Bernstein et al. 2022). Bangladesh's long experience with Nipah virus provides an institutional base, and the national One Health framework should be renewed and resourced with the environment and forest sectors as full partners (Government of Bangladesh 2017; FAO et al. 2022). Second, preparedness requires surge capacity and legal clarity before the event: critical-care beds, oxygen, laboratory networks, stockpiles of protective equipment and tested procedures for applying disaster and infectious-disease legislation together. Third, the response must be coordinated across ministries and communicated credibly. Late and contradictory announcements cost more than the measures themselves, and corruption in procurement and relief undermines compliance (Al-Zaman 2020).

Fourth, environmental management is part of the response and not an afterthought. Segregation, treatment and safe disposal of health-care waste, protection of waste workers and climate-resilient, low-carbon health facilities need to be written into emergency plans (WHO 2022), and wastewater surveillance should be maintained as routine infrastructure (Rogawski McQuade et al. 2023). Fifth, plans must assume concurrent hazards and protect livelihoods. Shelters and relief systems should be designed for outbreaks and cyclones or floods together, social protection should reach informal workers quickly, and food systems should keep working under movement restrictions (Amjath-Babu et al. 2020; Phillips et al. 2020).

DOI: https://doi.org/10.55706/jae1933

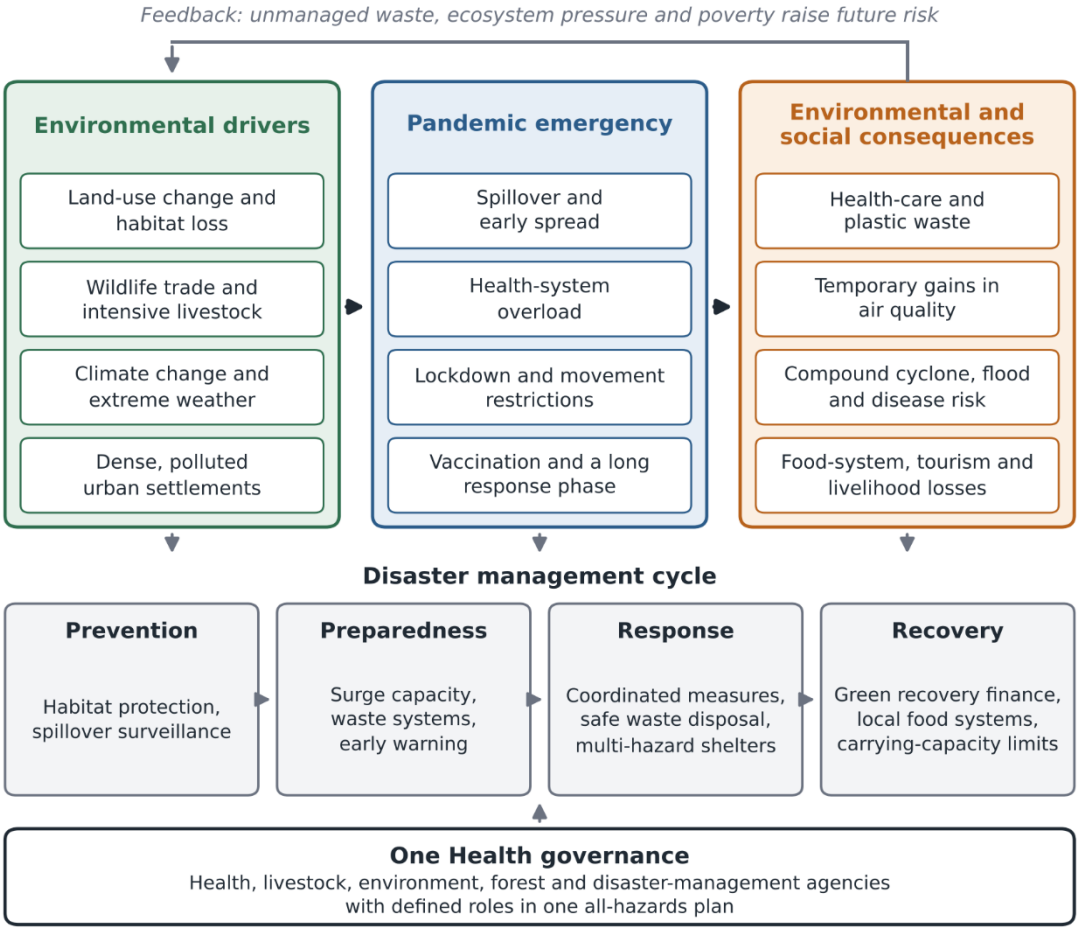

Figure 3. Conceptual framework linking environmental drivers, the pandemic emergency and its environmental consequences to the disaster management cycle under a One Health approach

The international framework has moved in this direction since the emergency ended. Amendments to the International Health Regulations adopted on 1 June 2024 introduced a new level of alert, the "pandemic emergency", and entered into force on 19 September 2025 (WHO 2024). The WHO Pandemic Agreement was adopted by the Seventy-eighth World Health Assembly on 20 May 2025. It covers prevention, preparedness and response, establishes a coordinating financial mechanism and a global supply chain and logistics network, and will open for signature once its annex on pathogen access and benefit-sharing is agreed (WHO 2025a). That annex was still under negotiation in May 2026, when Member States agreed to submit it either to a special session of the Assembly in 2026 or to the Eightieth World Health Assembly in May 2027 (WHO 2026). The One Health Joint Plan of Action 2022–2026 of the four international agencies includes the integration of the environment into One Health among its action tracks (FAO et al. 2022). The declaration of mpox as a public health emergency of international concern from 14 August 2024 to 5 September 2025 is a reminder that such events recur (WHO 2025b). For Bangladesh these instruments are an opportunity to revise the 2020 preparedness plan into an all-hazards, One Health-based plan in which environmental agencies have defined roles.

Table 5. Lessons from COVID-19 across the disaster management cycle and their environmental integration

Phase	Lesson from COVID-19	Environmental integration
Prevention and mitigation	Pandemic risk originates largely at the interface of people, animals and ecosystems	Protect habitats; regulate wildlife trade and live-animal markets; One Health surveillance covering bats, livestock and vectors
Preparedness	Surge capacity, testing networks and legal procedures must exist before the event	Health-care waste treatment capacity; climate-resilient, low-carbon facilities; wastewater surveillance; climate-informed early warning
Response	Timely, coordinated and credible decisions matter more than the stringency of measures	Waste segregation and safe disposal from the first day; protection of waste workers; multi-hazard shelters with water, sanitation and hygiene services

DOI: https://doi.org/10.55706/jae1933

Phase	Lesson from COVID-19	Environmental integration
Recovery	Livelihood, food-system and tourism losses persist after cases fall	Recovery finance conditioned on environmental outcomes; diversified local food production; carrying-capacity limits at destinations
Governance (all phases)	Fragmented authority and corruption weaken every other measure	Defined roles for environment, forest, livestock and disaster-management agencies in the national pandemic plan

CONCLUSION

COVID-19 showed that a pandemic is a disaster in the full sense used in disaster risk management: it has environmental root causes, it overwhelms routine systems for years, and its management has environmental and social consequences of its own. In Bangladesh the response relied on measures that were sound in design but were weakened by late and poorly coordinated decisions, very limited critical-care and testing capacity, governance failures and weak communication. Mass vaccination, by contrast, eventually reached about 70% two-dose coverage. The environmental record is mixed. Air quality improved sharply but briefly, whereas health-care and plastic waste grew far beyond the capacity to manage it, and a cyclone and floods arriving during the lockdown turned a health emergency into a compound one. Food systems and tourism, both closely tied to natural resources, absorbed heavy losses.

The main implication is that pandemic preparedness and environmental management should be planned together. This means investing in spillover prevention and One Health surveillance, including wastewater monitoring; building health-care waste systems and climate-resilient facilities before the next emergency; designing shelters, relief and social protection for concurrent hazards; supporting diversified local food production; and tying recovery spending to environmental outcomes. The amended International Health Regulations and the WHO Pandemic Agreement give Bangladesh a current framework for doing so. Because this review is narrative and relies partly on early, rapidly produced sources, primary research is needed on the long-term environmental legacy of pandemic waste, on the performance of multi-hazard shelters and on the contribution of local food systems to resilience.

Acknowledgement

The authors are grateful to the Department of Environmental Science and Technology, German University Bangladesh, for academic support, and to the researchers and institutions whose published work made this review possible.

Financial support

This research did not receive any specific grant from funding agencies in the public, commercial or non-profit sectors.

Availability of data and materials

No new data was generated in this study. All documents analyzed are cited in the reference list.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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