

INNOVATIVE NATURE-BASED FLOOD PROTECTION MEASURES FOR BANGLADESH: A REVIEW

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ABSTRACT

In erosion-prone hilly and platform regions, the demand for innovative, low-cost, and environmentally sustainable flood protection measures has become increasingly critical. Unlike many previous studies that focused mainly on conventional or single-approach engineering methods, this paper reviews practical nature-based alternatives that have demonstrated success across South and Southeast Asia. Through a comparative analysis of drainage geocomposites, vetiver grass, geomats, and perforated gabion dams, the study evaluates their effectiveness, economic feasibility, and adaptability to various hydrological and terrain conditions. The findings are particularly interesting: perforated gabion dams in Nepal's mid-hills, where annual rainfall exceeds 3,300 mm, reduced flow velocity by 20–35%, limited scouring to 0.7 meters, and decreased erosion by up to 60%, while costing nearly 40% less to maintain than conventional concrete structures. Similarly, vetiver grass in tropical countries such as Thailand and India reduced soil loss from 7.3 t/ha to as low as 2.5 t/ha, and significantly minimized surface runoff. Geomats have also shown notable success in protecting riverbanks and slopes exposed to heavy monsoonal flows. Based on these comparative results, it can be inferred that these nature-based techniques hold great potential for implementation in Bangladesh's erosion-prone and flood-vulnerable zones. Overall, their adaptability, affordability, and resilience indicate that such solutions are well-suited for broader application in developing countries with similar climatic conditions, rainfall patterns, and socio-economic limitations, offering a sustainable pathway toward long-term flood and erosion risk reduction.

Keywords: *Erosion, drainage-geocomposites, vetiver grass, geomats, flood-mitigation*

INTRODUCTION

Flooding is the world's most widespread destructive natural disaster globally, touching nearly every continent and income level. It arrives in many guises: rivers overtopping after long rain, cloudbursts that overwhelm city drains, storm surges pushing far inland and its damage is rarely distributed fairly. Flood risk is global and some recent occurrences depict the scenario very promptly to illustrate, in western Germany and Belgium (2021), a stalled storm system produced record rainfall, deadly flash floods in steep valleys, and billions in losses (GEER Association, 2021; Mohr et al., 2022); in the United States (Hurricane Harvey, 2017), days of extreme rain over a heavily urbanized floodplain made the event one of the costliest on record (NOAA, 2024; NCEI, 2024); in China's Henan Province (2021), cloudbursts flooded subway tunnels in Zhengzhou and an official investigation later set the death toll at 398 (State Council inquiry via media reports, 2022); in Mozambique (Cyclone Idai, 2019), storm surge combined with river flooding to inundate Beira and surrounding basins, triggering a major humanitarian response (UN OCHA/ReliefWeb, 2019) and in eastern Australia (2022), record peaks at Lismore followed "rain-on-wet-ground" conditions, overwhelming towns and river systems (Bureau of Meteorology, 2022).

Though flooding is a worldwide natural calamity, South Asia remains especially vulnerable due to its geographical location, monsoonal climate, and dense population. Bangladesh and India, in particular, face recurring seasonal floods that result in large-scale displacement, economic disruption, and loss of life (Mohammed et al., 2018). These flood events are further exacerbated by unplanned urban expansion, poor drainage infrastructure, deforestation, and climate-induced changes in rainfall patterns. The Intergovernmental Panel on Climate Change (IPCC) warns that climate variability will intensify extreme weather events in South Asia, making low-lying areas more susceptible to floods (IPCC, 2022).

Traditional flood management strategies such as levees, embankments, diversion channels, and reservoirs have been the mainstay in these countries. However, these methods often fall short due to improper maintenance, design limitations, and a lack of climate resilience (Alfieri et al., 2016). Levees can create a "levee effect," which encourages development behind the wall and shifting risk toward rarer, catastrophic failures or to reaches upstream and downstream when defenses are overtopped or breach (Di Baldassarre et al., 2015; Hutton et al., 2019). Diversion channels and floodways help during moderate events but can underperform in extreme floods, and their benefits may be offset by ecological disruption and by maintenance burdens that many cities struggle to meet (WaterPortal overview; Pervin et al., 2020). Reservoirs reduce peaks when they have space to store water, yet many in Asia were designed primarily for irrigation or hydropower rather than flood control, and their effective storage declines over time due to sedimentation, reducing reliability just as extremes intensify (OECD, 2024; Hu et al., 2009). Across the region, inadequate operations and maintenance especially of urban drainage regularly turns heavy rain into prolonged water-logging, while climate change raises the odds of compound flooding that existing infrastructure wasn't designed to handle (IPCC AR6 WGII, 2022; Manandhar et al., 2023). There is now a pressing need to explore and implement innovative, cost-effective, and environmentally sustainable flood mitigation techniques that work with local geomorphology and communities, complement engineered defenses, and remain effective under a changing climate (IPCC AR6 WGII, 2022).

This paper reviews four promising solutions - drainage geocomposites, vetiver grass, geomats, and perforated dams. These technologies have shown effectiveness in various countries and are adaptable to the socio-economic and environmental contexts of Bangladesh and India. Drainage geocomposites improve urban water flow systems, while vetiver grass serves as a biological barrier against soil erosion. Geomats help reinforce riverbanks, and perforated dams control floodwaters without disrupting ecological flow. Although each technology has encouraging results globally, they have rarely been assessed side-by-side under the demanding monsoon: delta conditions and socio-economic realities of South Asia, where high sediment loads, rapid drawdown, informal settlements, and maintenance constraints shape performance. Few studies have holistically analyzed multiple emerging flood-control technologies under a unified climatic and development lens; this review fills that gap by comparing

drainage geocomposites, vetiver grass, geomats, and perforated (permeable) dams within comparable monsoon–delta and socio-economic contexts.

In monsoon-prone South Asia and similar developing regions, the climatic fit of these four measures is their strongest asset. Drainage geocomposites help cities and embankments cope with cloudburst rain, rapid drawdown, and chronic water-logging by moving water quickly while filtering fine silts. Vetiver grass adds root-zone shear strength and traps sediment during high flows, giving a living buffer that can recover after storms. Geomats provide instant surface protection at the start of the rainy season and act as a scaffold for vegetation, stabilizing riverbanks exposed to intense runoff. Perforated (permeable) dams slow –not block –flows, encouraging sediment deposition and wave attenuation while keeping ecological connectivity. Understanding how globally tested technologies could perform in developing monsoon climates is essential for sustainable implementation of the technologies.

While there is a growing body of work on each measure, drainage geocomposites, vetiver grass, geomats, and perforated (permeable) dams: most studies assess them in isolation, using site-specific methods and metrics that limit cross-comparison. Comparative, context-based analyses under unified monsoon–delta conditions and shared socio-economic constraints (e.g., rapid urbanization, high sediment loads, limited maintenance capacity) remain scarce. Notably, only perforated dams have seen meaningful comparative performance evaluation across settings, leaving important questions unresolved for the other three technologies such as durability under rapid drawdown, performance during compound flooding, lifecycle cost and maintenance needs, and the benefits of hybrid designs. This paper provides an analytical review of four flood mitigation techniques, including a comparative evaluation for perforated dam performance.

The paper analyses each solution’s working mechanism, global performance, adaptability and feasibility and specially performs a comparative analysis for perforated dams. In this context, the goal of the study is to assess the global utility of these solutions and examine their potential application in Bangladesh and India for building climate-resilient and community-based flood defenses.

LITERATURE REVIEW

Flood risk management has been a longstanding focus in civil and environmental engineering, particularly in South Asia. Traditional structural measures such as embankments, levees, detention reservoirs, and diversion channels have been extensively employed in flood-prone regions like Bangladesh and India. While these systems have provided short-term relief, they often face challenges related to inadequate maintenance, aging infrastructure, and limited adaptability to the increasing impacts of climate change (Alfieri et al., 2016).

In light of these limitations, recent research and policy discussions have shifted toward more sustainable and adaptive strategies that integrate both engineered and nature-based interventions. Among natural solutions, vetiver grass has emerged as a promising tool for slope stabilization and erosion control. Truong (2000) demonstrated its success in tropical environments, highlighting its ability to significantly reduce surface runoff and reinforce embankment integrity. Rodriguez (1993) further validated its application in India, Vietnam, and Bangladesh, where it effectively minimized soil loss and water runoff. These findings are particularly relevant for the Chittagong Hill Tracts and other landslide-prone areas of Bangladesh, where cost-effective and easily deployable techniques are urgently needed.

Synthetic solutions have also gained traction for their reliability and adaptability in various contexts. Technologies such as geomats and drainage geocomposites offer durable, low-maintenance alternatives to traditional materials. Their efficiency in managing water flow and stabilizing slopes has led to increased use in urban areas, especially where concrete-based infrastructure struggles with intense rainfall. UNDRR (2020) emphasized their relevance in cities like Dhaka, where they are being adopted

for roadside slopes, canal banks, and urban drainage networks to mitigate waterlogging and erosion more effectively than gravel-based systems.

Mohammed et al. (2018) underscored the importance of transitioning to climate-resilient flood management, projecting intensified flood events in Bangladesh under global warming scenarios. They advocated for innovative, hybrid solutions that integrate structural innovations such as perforated dams and geomats with community-based, low-cost measures tailored to local geography. These approaches offer scalability and cultural adaptability, making them suitable for implementation across both urban and peri-urban settings.

Drainage geocomposites are used as internal drains in levees, embankments, floodwalls, and urban subgrades to move water rapidly while preventing soil migration (Koerner, 2011). Lab and field studies show high in-plane flow capacity, effective pore-pressure relief, and reduced seepage gradients; long-term monitoring of sheet drains reports durable discharge where filters are well matched to fines (Palmeira & coworkers; field evaluations over >10 years). Recent centrifuge modeling of levees with geocomposite chimney drains under flood loading reinforces their role in stabilizing saturated sections and mitigating rapid drawdown effects (GEOIN, 2024). Adaptability for South Asia stems from thin profiles (useful where right-of-way is tight), quick installation compared with granular drains, and compatibility beneath revetments; however, performance depends on QA/QC, filter criteria in silts, and maintenance access to outlets (USACE design notes; geosynthetics texts). Although results are promising, further localized assessment is needed to verify long-term performance and maintenance feasibility under monsoon intensities, fine silts, and rapid drawdown typical of South Asia.

Vetiver forms stiff, deep, fibrous roots that add near-surface shear strength, reduce rill formation, and trap sediment, with multiple reviews reporting large erosion reductions when compared to bare slopes (Rahman, 2020; Islam, 2003; recent reviews). In Bangladesh's coastal polders and embankments, programs planted vetiver hedges along tens of kilometers, reporting successful protection where establishment care and toe support were provided, evidence that bio-engineering can complement low-cost mechanical measures (Islam, CERP/DWMP case documentation). For monsoon climates, vetiver's "self-healing" canopy and sediment-trapping behavior suit recurring overland flow; key maintenance needs are early weeding, protection from grazing, and supplementary toe protection on high-energy banks (regional practice notes; reviews). Despite strong evidence for erosion control, context-specific trials are needed to quantify survival, rooting strength, and sediment capture across varied flood regimes, grazing pressures, and community maintenance capacity.

Open-structure geomats provide immediate surface protection against rain splash and shallow overland flow, anchoring seeds/soil until vegetation establishes; they are widely applied on steepened slopes and riverbanks, often beneath or with vegetation (Markiewicz, 2024 review). Natural-fiber variants (coir, jute) are attractive where local supply chains exist and environmental criteria matter; studies highlight adequate short-to-medium durability, good soil contact, and benefits as a scaffold for root growth in humid tropics (Azmi et al., 2025; JGT efficacy studies). In large rivers or wave-exposed reaches, mats are best paired with toe countermeasures (e.g., geobags/riprap) or internal drainage to withstand drawdown—an integration increasingly reported in South and Southeast Asian casework (applications syntheses). While geomats show consistent near-surface protection, comparative field studies are needed to test material lifespans (synthetic vs. jute/coir) and toe-protection pairings under high sediment loads and seasonal inundation.

Permeable or "perforated" dams (e.g., bamboo/brushwood arrays on poles) slow, rather than block, flows - damping waves, promoting fine-sediment accretion, and maintaining ecological connectivity; 10–15-year syntheses from mangrove-mud coasts report elevation gains where porosity and maintenance are managed (Winterwerp et al., 2020; Delft/Deltares lessons). Laboratory and flume studies compare permeable-dam configurations and materials, showing strong sediment interception under cascade layouts and clarifying trade-offs between porosity, backwater rise, and discharge capacity (Liu et al., 2023; additional overviews). Compared with solid barriers or hard revetments, permeable

systems can achieve hydraulic efficiency (attenuation and accretion) with lower ecological disruption and adaptive O&M, though they require multi-season sediment budgets and periodic re-filling to retain performance (Winterwerp et al., 2020). Encouraging accretion and wave-attenuation results warrant site-specific evaluations that benchmark hydraulic efficiency, porosity management, and O&M needs against traditional hard defenses in monsoon-delta settings.

Each measure targets a different point in the flood pathway and works best in combination. Perforated (permeable) dams lower external energy and foster accretion; geomats give immediate surface stability; **vetiver** adds living shear strength and sediment trapping; and drainage geocomposites relieve internal pore pressure so surfaces and vegetation perform reliably. Layered together from foreshore to bank face to embankment core, they convert damaging peaks into slower, safer flows while improving recovery between events. This cross-analysis identifies context-dependent strengths rather than direct competition among methods, showing how to assemble practical hybrids for monsoon-prone, resource-constrained settings.

Existing studies typically examine these measures - drainage geocomposites, vetiver systems, geomats, and perforated (permeable) dams, one at a time, using site-specific metrics that hinder comparison and rarely foregrounding regional applicability in monsoon-delta contexts. As a result, we lack a coherent, side-by-side understanding of performance under shared constraints (high sediment loads, rapid drawdown, limited maintenance capacity, and rapid urbanization). The findings

Collectively, these developments in the literature highlight a growing consensus that flood management in developing nations like Bangladesh must evolve. Proactive, ecosystem-integrated, and locally adaptive strategies are essential to ensuring long-term resilience in the face of climatic and hydrological uncertainties.

METHODOLOGY

This study employs a qualitative research methodology based on a detailed review of secondary sources, including journal articles, case studies, technical reports, and documented field observations. Flood-mitigation technologies - drainage geocomposites, vetiver grass systems, geomats, and perforated dams were selected using specific criteria: proven effectiveness in flood-prone regions, relevance to South Asian terrain and hydrological conditions, cost feasibility, and environmental sustainability. The analysis examines each technology in terms of its global application, practical performance, and adaptability to the contexts of Bangladesh. Data were synthesized from published literature and validated field-based findings where these measures have been implemented. A comparative assessment was conducted focusing on (a) application practices, (b) effectiveness, (c) implementation methods, and (d) cost-related outcomes, drawing on experiences from Bangladesh and international case studies. This approach enables an evaluation of performance under varying environmental and socio-economic conditions and highlights how lessons from global practice can inform more context-appropriate flood-mitigation strategies for Bangladesh and other countries with similar climatic and socio-economic condition.

RESULTS & DISCUSSION

1.1 Drainage Geocomposites

Drainage Geocomposites are thin, factory-bonded drains -a cusped or geonet core laminated with one or two geotextile filters that move water rapidly within the sheet while keeping fines out. In flood assets and dense cities they help **relieve** pore pressure, lower exit gradients, and speed post-storm recovery failure modes that show up repeatedly in monsoon climates. Design guidance and field documentation support their use as chimney/finger drains in levees and as behind-wall drainage where granular backdrains are hard to build (USACE, 1989; USACE, 2022); (McKean & Inouye, 2000); (McKean et

al., 2001). Recent centrifuge studies show levees fitted with geocomposite chimney drains develop lower transient pore pressures and better stability under flooding and rapid drawdown - evidence that translates well to South Asian hydrology [(Saran et al., 2018); (Kumar et al., 2023); (Viswanadham et al., 2024)]. For Bangladesh, where Khulna and other cities repeatedly report water-logging during heavy monsoon rain and congested drainage, drainage geocomposites are a practical add-on: they fit tight rights-of-way, work in silt-rich soils when filter criteria are respected, and sit neatly behind flood/retaining walls or beneath revetments to keep surfaces serviceable through peak seasons [(Sarkar et al., 2016); (Sarkar et al., 2021)].

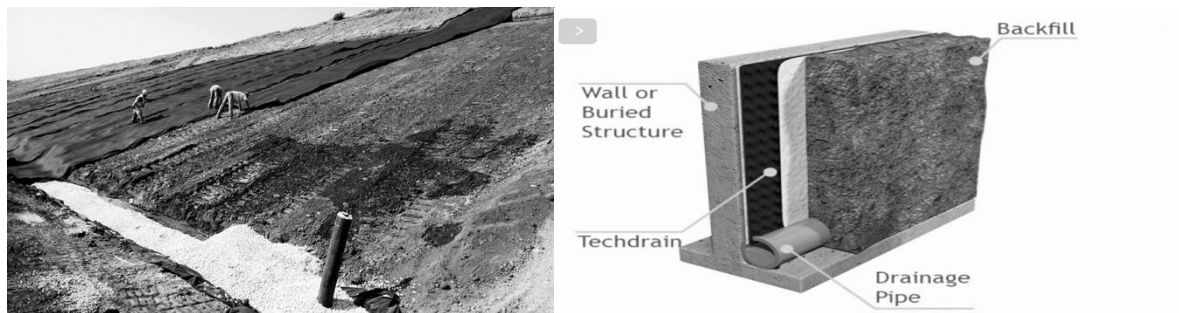


Figure 1: Installation of drainage geocomposites

Long-term monitoring in the United States recorded sustained discharges up to 100 L/min from vertical sheet drains on saturated cut slopes, with no rise in the down-gradient water table during storms, and stable performance over ≈ 14 years, useful benchmarks for maintenance-limited settings [(McKean & Inouye, 2000); (McKean et al., 2001)]. U.K. rail projects have used geocomposite wall drains behind sprayed-concrete facings to provide high flow capacity with rapid installation where space is at a premium (case documentation). South Asian centrifuge/modeling work (India) reports pore-pressure relief and improved stability for embankments equipped with geocomposite chimney drains, underscoring transferability to monsoon deltas [(Saran et al., 2018); (Kumar et al., 2023); (Viswanadham et al., 2024)]

Drainage geocomposites (DGCs) are well matched to Bangladesh's monsoon realities for example intense downpours, chronic water-logging, tight rights-of-way etc because they provide thin, high-capacity internal drainage behind walls, beneath revetments, and within embankments when granular backdrains are impractical (USACE, 1989; USACE, 2022). While Bangladesh's literature documents the necessity for added drainage in cities like Khulna, it offers little local performance data for DGCs, pointing to a clear pilot gap (Sarkar, 2016; Sarkar et al., 2021). In contrast, long-term U.S. field studies on saturated cut slopes and wall backfills report sustained discharges up to ~ 100 L/min with no rise in adjacent water levels and stable performance over about 14 years evidence for durability and manageable O&M (McKean & Inouye, 2000; McKean et al., 2001). The U.K. rail sector demonstrates large-area, rapid installation of geocomposite wall drains where space is constrained, underscoring buildability at scale (ABG Geosynthetics, 2024). Additionally, in monsoon-affected India, centrifuge and modeling work shows that adding geocomposite chimney drains lowers transient pore pressures and improves levee stability under flood rise and rapid drawdown mechanistic support that translates well to deltaic embankments (Saran et al., 2018; Kumar et al., 2023; Viswanadham et al., 2024). Together, these findings suggest DGCs are technically suitable for Bangladesh now, with the priority being locally monitored pilots to convert strong external evidence into Bangladesh-specific guidance (USACE, 1989; USACE, 2022; Sarkar, 2016; Sarkar et al., 2021; McKean & Inouye, 2000; McKean et al., 2001; ABG Geosynthetics, 2024; Saran et al., 2018; Kumar et al., 2023; Viswanadham et al., 2024).

1.2 Vetiver Grass Technology

Vetiver grass (*Chrysopogon zizanioides*) has gained international recognition as a natural solution for erosion control and slope stabilization. Its root system, which can grow up to 3 meters deep, binds the

soil and resists shear forces, making it especially useful in regions with heavy rainfall and slope instability (Truong, 2000).

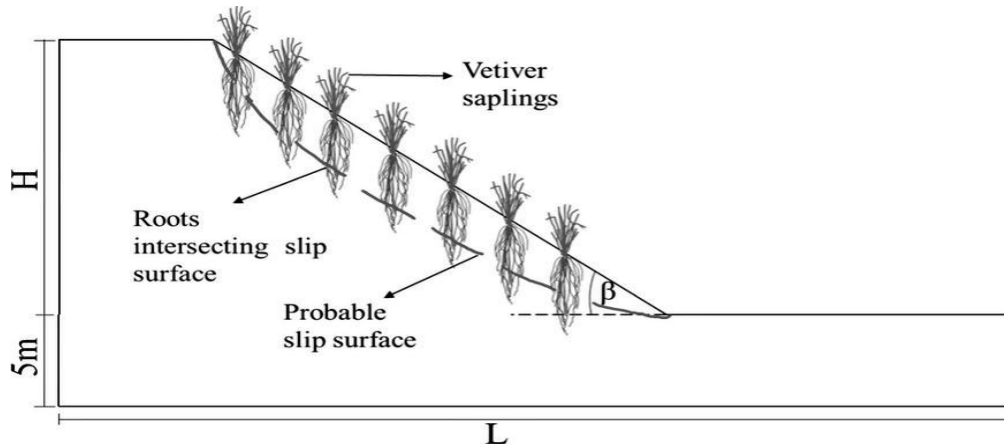


Figure 2: Slope protection mechanism of Vetiver grass

In Bangladesh, the application of vetiver is gaining momentum in hill tracts such as Bandarban, Khagrachhari, and Rangamati, where landslides pose a serious threat during monsoon seasons. Its non-invasive nature and ability to survive in nutrient-poor soils make it a sustainable option. Additionally, vetiver plantations are low-cost and require minimal maintenance, which is ideal for rural or resource-constrained regions. Its adaptability and proven efficacy make it an excellent candidate for large-scale application in both urban and rural flood defense systems.

Table 1: Comparative analysis of effect of vetiver grass on soil loss & runoff

Country	Soil Loss (t/ha) - Conventional	Soil Loss (t/ha) - Vetiver	Runoff (% of Rainfall) - Conventional	Runoff (% of Rainfall) - Vetiver
Thailand	7.3	2.5	1.4	0.8
Venezuela	88.7	20.2	50	21.9
Vietnam	5.7	0.8	76	72
Bangladesh	42	6-11	-	-
India	25	2	23.3	15.5

Note: Collected from Rodriguez, R. (1993). Vetiver grass for erosion and runoff control.

The table highlights that vetiver grass significantly reduces soil loss and runoff compared to conventional slopes in various countries, with notable decreases in both soil erosion and water runoff, especially in regions like Thailand, Venezuela, and Vietnam. For example, in Thailand, soil loss reduced from 7.3 t/ha to 2.5 t/ha, and runoff decreased from 1.4% to 0.8%, demonstrating the effectiveness of vetiver grass in controlling soil erosion and water flow.

1.3 Geomats for Riverbank and Slope Control

Geomats, composed of polymeric or natural fibers, act as surface protectors that stabilize slopes and riverbanks against erosive forces. When combined with hydroseeding, geomats also promote vegetation growth, enhancing long-term slope stability. International applications, such as in Brazil and India, have shown that geomats are effective even under high-flow conditions (Mohammed et al., 2018).

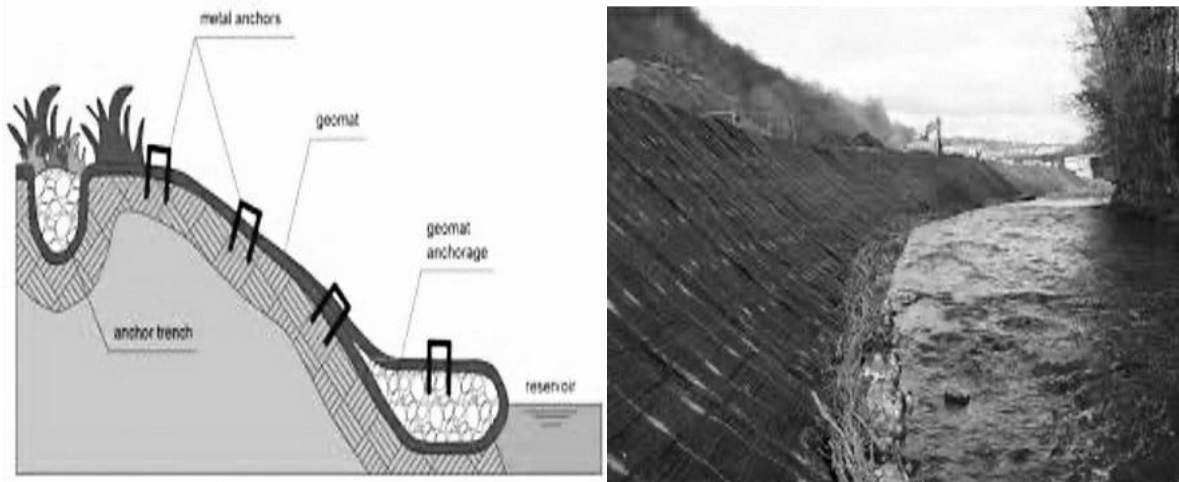


Figure 3: Geo-mats structural mechanism (Left) and application of Geo-mats at riverbank slopes

Bangladesh, severe riverbank erosion along the Padma, Jamuna, and Meghna rivers displaces thousands of people annually. Areas like Harirampur in Manikganj and Naria in Shariatpur are particularly vulnerable. Geomats, when applied in these areas, reduce the velocity of water at the soil interface, thereby minimizing erosion and allowing vegetation to take root. Their deployment does not require heavy equipment and can be implemented through community labor, making it a low-cost, high-impact intervention.

Geomats are being used in Bangladesh mainly on freshly graded canal and riverbank faces to hold soil and seed through the first monsoon bursts, often as part of pilot works that pair the mats with vegetation and simple toe measures; for example, FRERMIP pilots tested grout-filled jute “mattresses” and bio-engineering on vulnerable embankment reaches in central Bangladesh to reduce wave/surficial erosion and help plants establish (ISSMGE case study). Studies from other countries show that geomats work in a similar way everywhere. Tests done in laboratories and in the field found that jute and coir mats can reduce soil erosion on slopes by about 94–99%, meaning most of the soil stays in place instead of being washed away (Kalibová et al., 2016). In riverbank projects in India and Malaysia, coir mats often used together with coir logs or vetiver grass have helped slow down bank erosion and allowed plants to grow back. In one project in Malaysia, erosion was reduced by about 90%, showing that these natural mats can be very effective when properly installed.

1.4 Perforated Dams for Flood Regulation

Perforated or flow-through dams are engineered to moderate floodwater by permitting a controlled release. Unlike conventional dams that store water, these structures maintain partial flow, reducing pressure on downstream zones and improving sediment transport. This gradual flow also helps manage sediment by letting it move naturally, preventing buildup behind the dam and reducing erosion. They are especially useful in regions with limited storage space or where ecological flow must be maintained (Nath, 2019). In flood-prone districts of Bangladesh, especially low-lying areas like Sunamganj and Kurigram, perforated dams could provide a dual function of flood management and ecosystem protection. By allowing sediments to pass through, they avoid siltation issues seen in traditional dam structures. Their modular design and adaptability to river hydrodynamics make them practical for both permanent and seasonal flood control efforts. Importantly, they can be constructed using locally available materials, thus keeping the costs manageable.

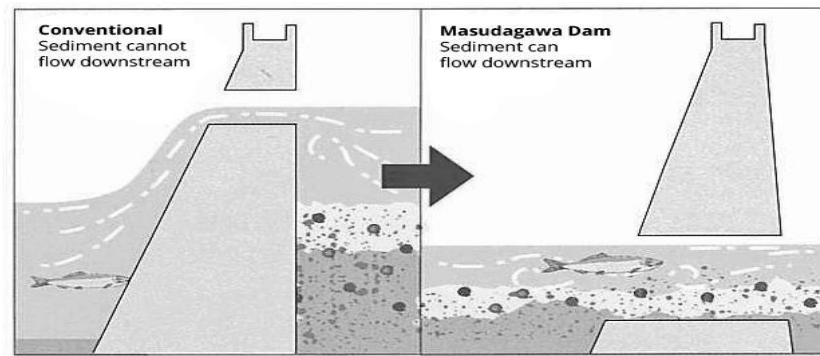


Figure 3: Comparison between conventional & flow - through dam in flow and sediment control

Table 2: Comparative analysis of perforated dam application in Nepal & Bangladesh hill tracts

Parameter	Nepal (Hill Rivers)	Bangladesh (Hill Tracts)
Average Monsoon Rainfall	3,345 mm (Pokhara, mid-hills)	2,500 – 3,500 mm
Average River Flow (m ³ /s)	170 m ³ /s	340 – 5,566 m ³ /s (e.g., Sangu, Matamuhuri)
Slope of River	1 – 3%	1 – 3%
Flow Reduction from Perforated Dams	20 – 35%	N/A (yet to be tested)
Erosion Reduction	40 – 60% (after 5 years)	N/A
Cost of Installation (USD)	1,200 – 1,500 per structure	Over 250/m (current methods)
Monsoon Flood Control	Decreases flood peaks by 20-30%	N/A

Severe riverbank erosion in the Chittagong Hill Tracts, driven by steep gradients (1–3%) and heavy monsoonal rainfall (2,500–3,500 mm annually, 80% during June–September), often overwhelms traditional impermeable structures, causing backpressure and scouring (BMD, 2021; LGED, 2019). In Nepal’s mid-hills, with similar gradients and rainfall over 3,345 mm (e.g., Pokhara), perforated gabion dams have reduced flow velocity by 20–35%, controlled scouring up to 0.7 meters, and decreased erosion by 40–60% over five years, while maintaining sediment flow and reducing flood peaks (Department of Hydrology and Meteorology, Nepal, 2022; Shrestha et al., 2021).

In Nepal, perforated dams cost USD 1,200–1,500 using local materials like boulders, bamboo, and geotextile, with 30–40% lower maintenance costs than traditional concrete revetments (ADB, 2018). In Bangladesh’s erosion-prone zones like Bilaichhari and Barkal, where current methods cost over USD 250 per meter and often fail, these dams offer a sustainable, cost-effective alternative (MoWR, 2020). With similar climate and topography, piloting this solution in Bangladesh’s hill tracts and riverbanks is a logical step towards enhancing flood resilience (ICIMOD, 2020).

LIMITATIONS

Although these technologies are promising, their use in Bangladesh has some practical limits. Drainage geocomposites need careful design, good installation, and regular outlet checks; in fine, silty soils they can clog if not properly maintained. Vetiver grass works well only if it establishes successfully, but survival can be low where embankments are deeply flooded, exposed to waves, or poorly maintained. Geomats, especially jute or coir mats, provide short-term protection and may fail on high-energy riverbanks unless combined with toe protection. Perforated dams require suitable sites and ongoing maintenance, and their performance can be uncertain in rivers with highly variable flows and sediment loads.

Despite these limitations, these technologies are highly applicable as nature-based solutions for flood mitigation in Bangladesh, as they work with natural processes, use locally available materials, and can be adapted to the country’s climatic and socio-economic conditions.

CONCLUSIONS

The adoption of innovative flood protection measures such as drainage geocomposites, vetiver grass, geomats, and perforated dams presents a multifaceted approach to mitigating flood risks in Bangladesh, India and other similar countries. These technologies, individually and in combination, can enhance flood resilience while promoting environmental sustainability. However, for successful implementation, they must be integrated into national development and disaster risk reduction policies, supported by stakeholder engagement and technical capacity-building. Future research should focus on long-term pilot programs, regional customization of these technologies, and the economic assessment of their benefits to promote widespread adoption.

DECLARATION OF USE OF AI

During the preparation of this work, the authors used ChatGPT by OpenAI only to improve clarity and readability in the writing only. The initial draft was written entirely by the authors. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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