RESILIENCE BY DESIGN: HARNESSING INFRASTRUCTURE AND PUBLIC–PRIVATE PARTNERSHIPS FOR DISASTER RISK REDUCTION IN MALAYSIA

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When disaster strikes, the strength of a nation is measured not only by its response, but by how well it has prepared to withstand the blow. In Malaysia - where monsoonal floods, landslides, and coastal erosion increasingly threaten lives and livelihoods - the role of infrastructure is no longer confined to powering growth. It is the backbone of national resilience. From Kuala Lumpur's SMART Tunnel, which doubles as a traffic artery and a flood bypass, to coastal embankments shielding fishing villages, Malaysia has proven that the right projects, properly maintained, save lives and money. According to the United Nations Office for Disaster Risk Reduction, every $1 invested in prevention measures can generate savings of up to $15 in post-disaster recovery expenditure.

Malaysia's experience shows that a well-planned infrastructure programme can significantly reduce disaster impacts. Yet the next leap will require not only better engineering, but also innovative financing and delivery models. This is where Public–Private Partnerships (PPPs) should play a central role: unlocking private capital, transferring know-how, and ensuring long-term maintenance discipline.

A shifting risk landscape demands resilient infrastructure

Malaysia now faces a heightened spectrum of disaster risks, amplified by climate change and rapid urbanisation. Urban expansion has encroached on floodplains. Heavier rainfall overwhelms older drains. Slope development amplifies landslide risks, while rising seas threaten coastal settlements. These are not abstract scenarios - every flood season disrupts commerce, damages homes, and erodes investor confidence.

Infrastructure is our first line of defence, but "more of the same" will not suffice. Building more drains, levees and walls is no longer sufficient. Resilient assets must be planned for exceedance (beyond average rainfall), absorbing shocks without catastrophic failure, and rapid restoration - while delivering co-benefits in normal times. PPPs add a crucial dimension: structuring projects so that resilience is contractually guaranteed over decades, rather than left to overstretched public budgets.

Malaysian successes: Infrastructure that saves lives – SMART Tunnel, Kuala Lumpur

This is the world's first dual-purpose road and stormwater tunnel, conceptualised on a PPP basis. This infrastructure blends mobility and flood defence. Though delivered conventionally, it demonstrates the "multi-functionality" principle that PPPs are well suited to capture in contracts. On normal days, it functions as a motorway, easing traffic congestion in the city of Kuala Lumpur. During heavy rain, it transforms into a flood bypass, diverting millions of cubic meters of stormwater away from the city centre. Since completion of construction and during operational period, SMART has prevented countless floods in the Klang Valley's most vulnerable areas, proving that innovative design can solve multiple urban challenges at once.

Flood mitigation in Kedah, Kelantan, Johor and Sarawak

River bunds, detention ponds, retention ponds, levees, floodwalls, river channel upgrades, and upgraded pumps have reduced flooding frequency. Yet long-term operation and maintenance ("O&M") remains a challenge. Embedding these works in PPP structures - with private operators accountable for pump availability, drainage capacity, and maintenance - would lock in resilience performance.

Slope management in Penang and Cameron Highlands

Retaining walls, soil nailing, and drainage upgrades have curbed landslides. A PPP model could deliver these as programmatic bundles, covering multiple slopes under a single contract with monitoring sensors, parametric insurance, and lifecycle maintenance obligations.

Coastal protection in Sabah and Terengganu

Sea walls and breakwaters shield villages from erosion. Here too, PPP models could mobilise private capital for hybrid coastal defences, where availability payments are tied to reduced overtopping incidents or maintained protective width.

In a PPP, availability payments are regular payments made by the government (or contracting authority) to the private partner, as long as the infrastructure is available and performing to agreed standards.

- They are not linked to demand or user fees (e.g. tolls or ticket sales).
- Instead, they are tied to service quality and performance indicators - like safety, reliability, or resilience.
- If the infrastructure fails to meet the agreed criteria, payments are deducted (penalty for non-performance).

The lesson is not only that infrastructure works, but that PPPs can institutionalise resilience standards and secure O&M funding, reducing the risk of assets failing prematurely.

Global models and PPP lessons for Malaysia

I. Netherlands – "Room for the River" (Design–Build–Finance–Maintain)

While much of the Dutch programme was publicly funded, certain works used long-term PPP contracts that tied payment to flood resilience performance. Malaysia could adopt similar approaches: floodable parks and diversion channels delivered as PPPs, with revenue-sharing from adjacent land redevelopment.

II. Japan – Seismic PPP schools and hospitals

Private partners design, finance, and maintain public buildings to seismic standards. Malaysia could replicate this approach for schools doubling as flood shelters, ensuring durability and continuous readiness.

III. Bangladesh – Cyclone shelters and embankments

While largely public, donors are now piloting PPP-style O&M contracts for embankments. Malaysia's coastal districts could embark on trial PPP models for multipurpose community shelters, backed by blended finance.

IV. Chile – Concessioned infrastructure with seismic standards

Roads, bridges, and airports under concession contracts must meet strict earthquake resilience codes, with private operators liable for rapid recovery. Malaysia can embed similar requirements in PPP contracts for toll roads and ports in flood-prone areas.

V. Singapore – Marina Barrage

This is a multi-functional dam and reservoir that serves as a key part of Singapore's water management and flood control system. It creates the Marina Reservoir, a freshwater source in the heart of the city, whilst acting as a barrier to prevent flooding from sea surges and heavy rain. The Barrage also provides recreational spaces and is a popular tourist destination. Though publicly funded, its operation could easily lend itself to a PPP framework: performance-based O&M contracts ensuring flood control reliability, water quality, and energy efficiency.

The global lesson is clear: PPPs are not just financing tools - they are governance mechanisms that lock in long-term resilience by aligning private incentives with public safety.

PPPs as a vehicle for resilience financing

Resilient infrastructure is capital-intensive, but it can be structured to attract investment if service outputs are predictable.

- **Performance-based PPPs**
  Instead of paying for inputs (a pump station or levee), government pays for outputs: e.g., "maximum water level not exceeded in basin", "drainage system operational 99% of the time". Private operators bear lifecycle responsibility, incentivising preventive maintenance.

- **Blended finance PPPs**
  Concessional loans or guarantees from development banks (ADB, AIIB, World Bank) can lower the risk premium for resilience PPPs, particularly where climate hazards are uncertain.

- **Green sukuk and resilience bonds**
  Malaysia's leadership in Islamic finance positions it to issue resilience-linked sukuk for PPPs bundling multiple mid-size flood and slope projects. Institutional investors, particularly pension funds, are natural long-term partners.

- **Insurance-linked PPPs**
  Contracts can embed parametric insurance to cover extraordinary rainfall or surge events, ensuring both operator and government are protected.

Policy And Legal Frameworks To Enable PPP Resilience

Malaysia already has a PPP framework, but embedding resilience standards requires adjustments:

- Mandating climate risk assessments at project preparation stage.
- Allowing availability-based PPP payments tied to resilience outcomes.
- Encouraging catchment-scale PPPs (bundling multiple flood assets into one contract).
- Requiring private operators to integrate nature-based solutions - mangroves, wetlands, green buffers - into designs.
- Enhancing cross-agency coordination so that PPPs integrate with NADMA and local authority planning.

From Concept To Bankable PPPs: Pipeline For Resilient Infrastructure

To translate disaster-resilient infrastructure from concept to implementation, Malaysia must prioritise a pipeline of PPP-ready projects that not only protect communities but also demonstrate commercial viability and attract long-term capital. Four potential models stand out:

I. Klang Valley Detention Parks PPP

Flooding remains the most frequent disaster risk in Malaysia, particularly in the Klang Valley. Instead of relying solely on concrete drains and culverts, the government could pursue PPP for a network of floodable parks, smart drains and detention ponds, designed as multifunctional green infrastructure.

- The parks would function as community recreational spaces in dry conditions, while doubling as temporary stormwater storage during heavy rains.
- Private partners could be engaged to design, finance, build, and maintain the system.
- Payments from government would be structured as availability payments, tied to measurable flood outcomes such as reductions in peak flows into critical waterways like Sungai Klang.

This model would showcase how infrastructure can be both people-friendly and climate-resilient, while embedding private-sector efficiency into long-term operations.

II. East Coast Hybrid Coastal Defence PPP

Malaysia's East Coast is increasingly exposed to storm surges and coastal erosion. A PPP could be structured to deliver hybrid defences that combine hard infrastructure (breakwaters, revetments) with nature-based solutions (mangrove restoration and beach nourishment).

- Financing could be mobilised through sukuk (Islamic bonds), widening the pool of institutional investors and aligning with Malaysia's leadership in Islamic finance.
- The private consortium would be responsible for both the engineering works and long-term ecosystem management, with performance guarantees tied to coastal protection metrics such as reduced overtopping or maintained mangrove width.

This would mark Malaysia as a regional leader in green-blue PPPs, setting an example of how financial innovation and ecological design can reinforce each other.

III. Slope Safety PPP for the Highlands

Highland regions like Cameron Highlands and Genting face increasing landslide risks due to deforestation, heavy rainfall, and rapid development. A programmatic PPP could be developed to address slope safety at scale:

- The private partner would undertake a portfolio of slope stabilisation measures - such as soil nailing, retaining walls, vegetation cover, and smart sensors for real-time monitoring.
- Government payments would be tied to slope stability performance indicators, with parametric insurance embedded in the PPP contract to ensure rapid payouts if rainfall or ground movement exceeds pre-defined thresholds.
- This approach would replace piecemeal, reactive repairs with a long-term, preventive system, giving both residents and investors greater confidence in Malaysia's highland safety.

IV. Urban Tidal Control PPP

Coastal cities like Johor Bahru and George Town (Penang) are already experiencing tidal flooding linked to sea-level rise and land subsidence. A PPP pilot could deliver

tidal gates, pumping stations, and sea walls, integrated with urban regeneration schemes along the waterfront:

- Financing could include land value capture mechanisms, where the uplift in land and property values from revitalised, flood-protected waterfronts is channelled back into the project.
- The private consortium would be incentivised to maintain the defences at peak performance, as payments would be conditional on minimised tidal flooding incidents.
- Beyond flood control, such projects would catalyse economic development and tourism, showing how resilience infrastructure can be both protective and catalytic.

Conclusion: PPPs As A Catalyst For Resilience

Malaysia has shown that infrastructure can protect lives and livelihoods. The next frontier is to scale resilience through delivery models that guarantee long-term performance. Public–Private Partnerships are not a panacea, but they are powerful enablers - mobilising private capital, embedding lifecycle accountability, and aligning innovation with public safety.

If resilience is embedded into PPP contracts through measurable outcomes, innovative and blended financing, and strong enforceable legal frameworks, Malaysia can shift decisively from reactive disaster response to proactive risk reduction and prevention. In doing so, it can not only safeguard communities but also demonstrate regional leadership in financing and delivering resilient infrastructure.

It is highly commendable that Malaysia has already formalised its Disaster Risk Reduction ("DRR") agenda through the National Disaster Risk Reduction Policy 2030, launched by NADMA in 2024. This policy aligns with the Sendai Framework and cements DRR as a cross-sector requirement, such that infrastructure, land-use, and development projects must systematically integrate hazard and climate resilience considerations from the outset. For the infrastructure sector, this is a clear signal: resilience is no longer a "value-add" but a compliance and investment driver, opening the door to large-scale, well-funded projects nationwide.

Resilience is not a luxury; it is the currency of sustainable growth. With PPPs as a catalyst, Malaysia can transform its infrastructure landscape into one that not only withstands shocks but powers sustainable growth. The choice is clear: by building resilience into every contract and every project, Malaysia can engineer a safer, stronger, and globally competitive future.

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