



APCTT
Asian and Pacific Centre
for Transfer of Technology

Consolidated Reply

Query 8 -

Leveraging Digital Twins for Climate Action & Resilience in Asia-Pacific

**Community of Practice (CoP)
on Climate Technologies**



APCTT
COMMUNITY OF PRACTICE
ON CLIMATE TECHNOLOGIES



Community of Practice (CoP) on Climate Technologies

Shared Experiences, Smarter Solutions for Climate Action and Resilience

The Community of Practice (CoP) on Climate Technologies, launched by the Asian and Pacific Centre for Transfer of Technology (APCTT), aims to address climate change challenges in the Asia-Pacific region through technology cooperation and transfer. By leveraging the region's innovation capacities and good practices, the CoP enhances access to critical knowledge on climate technologies, fosters cross-border collaboration, and connects professionals engaged in delivering technological solutions to climate change. The objective of this Community of Practice is to:

- Promote collaborative problem-solving and policy-relevant dialogue
- Support the localization and transfer of innovations aligned with national priorities



Original Query by: Dr. Changbeom Choi, Hanbat National University, Republic of Korea

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Asia-Pacific cities and infrastructure are increasingly exposed to climate risks, including floods, heatwaves, and sea-level rise. Over 90% of the region's urban population is exposed to extreme weather events, which are estimated to intensify by 30-50% by 2050 under current trajectories. Addressing these risks requires not only improved data and modeling, but also tools to support real-world decision-making by planners, operators, and policymakers. Digital Twin technologies (virtual replicas that integrate IoT, AI, and satellite data) are emerging as powerful tools for predictive planning and climate resilience. However, their adoption across the region remains uneven and is largely limited to pilot initiatives.

In this context, we invite members to share their knowledge and lived experiences with the following questions:

1. Based on your experience, please give details of Digital Twin applications that were used to inform or support decision-making for climate resilience in Asia-Pacific contexts (for example, in urban flood management, coastal protection, or infrastructure planning) and across sectors like water, energy, or transport?
2. Please share your direct experience (for example, in designing or formulating policy frameworks, financing approaches, or cross-sector collaborations) on the deployment and scaling up of Digital Twin technologies for climate action. We welcome insights on how resource limitations, institutional capacity, and human expertise influenced the design, deployment, and scaling of Digital Twin solutions.



Your insights will support regional knowledge sharing and help inform inclusive approaches to using Digital Twin technologies for climate action and resilience across the Asia-Pacific region.

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1. Summary of Responses

The query on the applications, scaling and institutional challenges of Digital Twin (DT) technologies for mitigating climate vulnerabilities in the Asia-Pacific region evoked several responses.

On the sectoral applications in climate resilience, DTs have evolved from rudimentary data visualisation platforms to complex decision support systems. DTs now seamlessly integrate features such as Internet of Things (IoT) sensors, Artificial Intelligence and Machine Learning (AI/ML), satellite imagery, and Building Information Modelling (BIM) to assess the challenges from environmental risks. In urban flood and stormwater management, the [Virtual Singapore platform](#) exemplifies cutting-edge practice and uses LiDAR-based three-dimensional city models and real-time rainfall radar to inform enhancements in drainage infrastructure and pump operations.

Similar interventions are also observable in the [Republic of Korea](#) where municipalities implement AI-driven runoff simulations and satellite-based precipitation forecasts to simulate extreme [50 and 100-year rainfall occurrences](#). This is significantly enhancing the responsiveness of estuarine gate operations. Additionally, the integration of BIM and Geographic Information Systems (GIS) has helped planners visualise hydraulic scenarios and assess the impacts of flood depth on transportation corridors and utility networks. Similarly, DT has also helped advance coastal and energy infrastructure resilience. High-resolution [bathymetric data](#) and AI-augmented [erosion models](#) have helped design long-term relocation strategies for port infrastructure threatened by rising sea levels. In [Australia and the Pacific Island States](#), drone-derived imagery is fed into cloud-based DT models to facilitate ecosystem-based adaptation e.g. in restoration of mangrove ecosystems.

In the energy sector, [the Singapore Grid DT](#), covering both Asset and Network layers estimates potential stress points during extreme heat periods to stabilise grids. [Japan](#) utilises smart-grid DTs to optimise energy storage

and prevent the risks of power outages. In India, [Advanced Building Information Modelling](#) (6D–9D) is improving thermal resilience in metro and cold storage projects, supporting disaster simulations and carbon footprint minimisation. Finally, collaborative initiatives between [Denmark and Singapore](#) are aimed at the development of DTs for sustainable water-based cooling solutions in densely populated megacities.

On the question of implementation challenges and policy and institutional barriers, the transition from isolated pilot projects to institutionalised governance remains key, requiring DTs to be conceptualised as [risk-management instruments](#) rather than technology showcases. Also, integrating these systems into national [smart city strategies](#) can help ensure ongoing funding. There is an important [operational gap](#) — the disconnect between high-end analytical models and practical requirements of frontline responders in terms of resource constraints, fragmented institutional data, and limited technical capacity. [Data maturity and standardisation](#) are other challenges, as unstructured asset data frequently makes DTs act as basic visualisation layers rather than critical decision support systems. Another important gap is the [lack of ISO-style standards](#) to integrate Building Information Modelling with climate technologies across asset lifecycles.

Additionally, though public grants may initiate DT projects, long-term financial sustainability is difficult since the principal benefit of reduced disaster losses is difficult to quantify. There is also inadequate availability of [interdisciplinary professionals](#), who can bridge the fields of climate science, engineering, and [data analytics](#).

In conclusion, several strategic insights emerged, including the value of initiating high-impact, targeted use cases such as [specific flood zones](#), rather than city-wide platforms. Similarly, modular, [cloud-based architectures](#) are suited for resource-constrained environments and can support broader accessibility. DT outputs can also be integrated into capital budgeting and [urban planning cycles](#) to ensure institutional relevance. Finally, incorporating [social vulnerability data](#) into DTs could promote equitable and nature-based solutions.

2. Relevant Experiences

Disaster Risk Management

Country	Key Purpose & Role	Organizations Involved	Link
China	Real-time flood forecasting & basin flood simulation (Yongding River Basin, Beijing)	Ministry of Water Resources, IWHR, IFMS-2D	Link
India	Predicts urban flooding 48h prior (Mumbai)	BMC, IIT Bombay, IIT Madras, ISRO, Genesys International	Link
Japan	Earthquake/flood planning, crisis simulation & cross-agency data integration (Tokyo)	Tokyo Metropolitan Government, TerriaJS, Pacific Spatial Solutions, Mitsubishi Research Institute, Cesium ion	Link
Netherlands	Infrastructure impact & flood/climate scenario simulation (Rotterdam)	City of Rotterdam	Link
Republic of Korea	Comprehensive smart city digital twin incl. flood prediction, fire response, traffic & urban management (Incheon Metropolitan City)	Incheon Metropolitan City, Esri (ArcGIS)	Link
Tonga	Sea-level rise simulation & multi-hazard vulnerability — flood, drought, land subsidence (Tongatapu Island)	UNOOSA/UN-SPIDER, CEOS, NDRMO, SpaceData Inc.	Link

Climate Resilience & Sustainable Infrastructure

Country	Key Purpose & Role	Organizations Involved	Link
UK	Climate resilience of utility networks — Energy, Telecom, Water — via connected digital twins (England, national scale)	National Digital Twin Programme (NDTp), CDBB/Univ. of Cambridge, Anglian Water, BT, UK Power Networks, UKRI, Mott MacDonald	Link
USA	Energy sector & critical infrastructure safety and resilience (Houston, Texas)	City of Houston	Link
Uzbekistan	Safe & climate-resilient road construction (A380 highway, Karakalpakstan region, 25 km section)	Asian Development Bank (ADB), ORIS, Uzbek Committee of Roads	Link
Finland	Climate scenario simulation & energy performance (Helsinki)	City of Helsinki	Link
Italy	Air quality management & green space efficacy (Milan)	City of Milan	Link
Singapore	Urban heat assessment & city cooling strategies — national scale (Digital Urban Climate Twin, DUCT)	Singapore-ETH Centre, NSCC, SLA, GovTech	Link

3. Related Resources

Original Research/Report Title	Authors	Key Summary
Digital Twins for Smarter Iranian Cities: A Future Studies Perspective	Nader Zali, Ali Soltani, Peyman Najafi, Salima Ebadi Qajari, and Mehrdad Mehrju	Identifies challenges like sanctions and infrastructure; recommends DT for governance and digital investment.
Management of Climate Resilience: Exploring the Potential of Digital Twin Technology, 3D City Modelling, and Early Warning Systems	by Khurram Riaz, Marion McAfee, and Salem S. Gharbia	Recognizes DTs as enablers for disaster decision-making via real-time monitoring and remote sensing.
Enhancing Flood Resilience in Coastal Areas by Investigating Issues and Countermeasures Using Digital Twin Technology	Nur Arina Amirah Azlan, Abdul Rahimi Abdul Rahman, Bala Ishiyaku, and Ahmad Rizal Alias	Analyzes DT potential for flood monitoring; notes high costs of sensors and computing as a major impediment.
Linking Digital Twin Paradigm for Urban Heat Monitoring and Policy Integration to Building Smart City Climate Resilience	Mohammad Ismail Hossain, Md Refath Hossan, Zahid Hassan Shaon, and Md Nahid Ferdous	Simulates mitigation (green roofs, urban forestry) to help policymakers design cooling centers and building codes.
Digital Governance for Urban Resilience in Bangladesh: A Policy Framework Integrating Digital Twins and Federated Learning in Climate-Vulnerable Deltaic Cities	Pranab Kumar Panday	Proposes a governance framework integrating DT with Federated Learning for real-time flood risk simulation.



<p><u>Digital Twin Technology for Urban Flood Risk Management: A Systematic Review of Remote Sensing Applications and Early Warning Systems</u></p>	<p>Mohammed Hlal, Jean-Claude Baraka Munyaka, Jérôme Chenal, Rida Azmi, El Bachir Diop, Mariem Bounabi, Seyid Abdellahi Ebnou Abdem, Mohamed Adou Sidi Almouctar, and Meriem Adraoui</p>	<p>Systematic review showing DT's value in compound hazard forecasting; identifies data infrastructure gaps.</p>
<p><u>Digital Twin Frameworks for Enhancing Climate-Resilient Infrastructure Design</u></p>	<p>M.A. Rony and Samia Akter</p>	<p>Study of 210 professionals highlighting the importance of DT, data analytics, and leadership in risk assessment.</p>
<p><u>Smart Technological Urban Flood Management Strategies Are “Must-Do” Approaches: The Case of Chinese Coastal Megacity, Ningbo</u></p>	<p>Faith Ka Shun Chan, Weiwei Gu, Fang Zhang, Xiaolei Pei, Zilin Wang, Lingwen Lu, Ming Cheng, Yuhe Wang, Weiguo Zhang, and Yutian Jiang</p>	<p>Demonstrates improved resilience in Ningbo through 3D flood mapping and smart water technology during typhoons.</p>
<p><u>Development of Coastal Disaster Simulation System using Marine Digital Twin Technology</u></p>	<p>Hak Soo Lim, Sunghoon Hong, Jin Hyeok Park, Yunseo Choi, and Hunghwan Choi</p>	<p>Uses 3D GIS and AI to predict coastal disasters (typhoons, surges) through disaster scenario simulations.</p>
<p><u>Expediting Decarbonization in</u></p>	<p>Kai Chen Goh, Tonni Agustiono</p>	<p>Discusses applying the Industry 5.0 paradigm</p>



<p><u>Energy, Waste, and Water Sector through Digitalization in Sustainable Smart Cities (SSC): Case-studies in Malaysia and China Based on Industry 5.0 Paradigm</u></p>	<p>Kurniawan, Nadzirah Zainordin, Ika Diyah Candra Arifah, Muhamad Azahar Abas, Md Asrul Nasid Masrom, Sulzakimin Mohamed, Roshartini Omar, Sui Lai Khoo, Hun Chuen Gui, Tien Choon Toh, and Choo Wou Onn</p>	<p>and DT to speed up decarbonization in smart city sectors.</p>
<p><u>Digital Twin for Climate Resilience: Transforming Smart Cities for a Sustainable Future</u></p>	<p>Eslam Ali, Ahmed Mansour, Eslam Mohammed Abdelkader, Nehal Elshaboury, and Tarek Zayed</p>	<p>Reviews DT applications from individual green buildings to global networks for resource optimization.</p>
<p><u>Data-Driven Urban Digital Twins and Critical Infrastructure Under Climate Change: A Review of Frameworks and Applications</u></p>	<p>Mingyu Zhu and Jiayi Jin</p>	<p>Presents a conceptual framework for data-driven decision-making for urban systems under climate risk.</p>
<p><u>Climate Resilience and Energy Flexibility in Industrial Systems: A Scoping Review of Concepts, Technologies, and Policy Links</u></p>	<p>Zheng Grace Ma, Joy Dalmacio Billanes, Bo Nørregaard Jørgensen</p>	<p>Combines DT with Blockchain and Machine Learning to create a Climate Resilient Industrial Flexibility Framework.</p>



[Digital Twin for Multi-Hazard Coastal Infrastructure Resilience in India and Australia](#)

Coalition for Disaster Resilient Infrastructure (CDRI)

Uses LiDAR and AI for real-time monitoring and risk-informed planning of coastal underground infrastructure.

4. Relevant Organizations/Initiative

Organization / Initiative	Key Role & Activities	Link
Coalition for Disaster Resilient Infrastructure (CDRI)	Funds and coordinates global fellowship research on digital twin applications for disaster-resilient infrastructure; supports projects applying AI, geospatial data, and digital twins for multi-hazard coastal and seismic resilience, aligned with SDGs	<u>Link</u>
Asian Development Bank (ADB)	Pilots and finances digital twin-based infrastructure projects across Asia-Pacific; provides a Digital Twin Framework and toolkit to guide member countries in adopting the technology for climate-resilient road, port, and urban infrastructure	<u>Link</u>
Economic Research Institute for ASEAN and East Asia (ERIA)	Conducts regional policy research on deploying digital twins for "Deep Sustainability" across ASEAN smart cities; proposes interoperable governance frameworks to support decarbonization and climate adaptation in East Asia	<u>Link</u>
Destination Earth (DestinE)	EU flagship initiative led by ECMWF, ESA & EUMETSAT to build a high-resolution digital	<u>Link</u>



Organization / Initiative	Key Role & Activities	Link
	twin of the entire Earth system; enables simulation of extreme weather events and long-term climate scenarios to inform EU adaptation policy and the Green Deal	
International Research Centre on Artificial Intelligence (IRCAI) under the auspices of UNESCO	Recognizes and promotes AI-powered climate resilience solutions through its Global Top 100 programme; the Resilitix Climate Resilience Digital Twin — developed by Resilitix Intelligence — was recognized for assessing infrastructure vulnerability and supporting community-level adaptation	Link
Hexagon	Provides urban digital twin platforms integrating 3D city models, IoT sensors, and flood forecasting models for climate-resilient city planning, disaster mitigation, and emergency response; partners with Fujitsu to support cities across Asia and beyond	Link
Esri	Supports Asia-Pacific climate action through GIS-based geospatial platforms in collaboration with SPC and SPREP; helps Pacific island nations leverage spatial technology for sea-level rise monitoring, disaster resilience, and SDG reporting	Link
Twinview	Delivers a BIM-integrated building digital twin platform enabling facility owners and managers to monitor energy use, reduce carbon emissions, and progress toward Net-Zero; used for commercial buildings and campuses	Link

Organization / Initiative	Key Role & Activities	Link
The Pacific Community (SPC)	Operates Digital Earth Pacific, a satellite-based Earth observation platform providing free and open data to Pacific island governments for monitoring sea-level rise, coastal erosion, and disaster risk; supports digital twin development for climate-threatened nations such as Tuvalu	Link
Hiverlab	Southeast Asia-based spatial intelligence company deploying digital twin solutions for smart city management and disaster readiness; partners with government agencies including Singapore's GovTech and Malaysia's DBKL to integrate IoT and real-time urban data into 3D visualization platforms	Link
Future Digital Twin & AI (Asia)	Organizes senior-level industry conferences in Southeast Asia connecting energy operators, technology providers, and policymakers to accelerate digital twin and AI adoption for industrial asset resilience, supply chain optimization, and energy transition	Link

5. Responses in Full

1. [Sohail Akhtar, Senior Scientist, Pakistan Council of Scientific & Industrial Research \(PCSIR\) Lab Complex, Karachi, Pakistan](#)
2. [Deepak Reddy Wanga , BIM Coordinator, Jacobs, Hyderabad , India](#)
3. [Md Selim Reza, System Analyst, Ministry of Finance, Bangladesh](#)
4. [Rohit Raj, Research Trainee, Plant Science, BITS Pilani](#)
5. [Prasad Deshmukh, BIM Consultant , Neilsoft, India](#)
6. [Ms Cristina Macaraig , Founder/ President of Wired field Philippines, Inc., Philippines](#)
7. [Peter Gorm Larsen, Vice-Head of section, Professor at Department of Electrical and Computer Engineering, Aarhus University, Central Denmark, Denmark](#)
8. [APCTT INPUTS](#)

Responses:

1. **Sohail Akhtar, Senior Scientist, Pakistan Council of Scientific & Industrial Research (PCSIR) Lab Complex, Karachi, Pakistan**

Digital twins are revolutionizing climate issues and actionable tasks by creating high-fidelity, dynamic virtual replicas for real-time environments. The digital twins technology integrates real-time data, advanced simulations, adopts AI/ML and provide predictive analysis. Based on the latest developments in climate technology digital twin-based solutions are increasingly being developed to address climate change, and used to intersect with real-time data environments and to create futuristic learning

models. Climate Technologies deployment by help of Digital Twins are used across global Earth systems for urban infrastructures. In climate technologies, the digital twins serve as the bridge between complex Earth sciences ecosystems and actionable decision-making. Digital twins are designed in such a way to represent the operational overwrought system for climate. These technologies adopted for a particular region, re-transforms a climate model about a known place for environmental prediction. These usually prepare and respond to climate data and informed prior before disaster.

This idea fundamentally changing our capacity to safeguard communities and economies in an era of climate volatility. The integration of AI, high-performance computing, and IoT creates a dynamic feedback loop where digital twins infrastructure learns, adapts, and optimizes itself against evolving climate risk. For companies and organizations deploying climate technologies, usually performing on an integrated digital twin, which has capabilities to build & adaptive capacity, well before facing escalating vulnerability to climate shocks which traditional planning tools cannot anticipate.

See the visual below, it captures the urgency and innovation behind climate resilience efforts powered by digital twins. This image captures a futuristic control room where planners and policymakers interact with holographic maps of Asia-Pacific. Real-time overlays show flood risks, heatwave zones, and sea level rise projections. Augmented reality (AR) dashboards integrate IoT, AI, and satellite data, supporting predictive models for urban flood management, coastal protection, and infrastructure planning.



A dash board based systems could be like a dynamic, data-rich control room overlooking a stylized map of Asia-Pacific. On the screens showing following and including tools as:

- 1) **Digital twins of cities** pulse with real-time data for flood simulations, heatwave alerts, coastal erosion etc.
- 2) **IoT feeds and satellite overlays** stream into holographic dashboards.
- 3) **Planners and policymakers** interact with the models using AR interfaces, adjusting infrastructure plans and emergency protocols.

Digital twins are being used to simulate environmental systems, such as urban-heat islands, coastal flooding, and Fogs/Haze emissions management. Also, to test mitigation strategies and support net-zero goals. These models allow researchers to interact with real-time data and explore the impact of different climate policies or technologies. The digital twin tools help visualize long-term climate scenarios and support evidence-based decision-making.

2. Deepak Reddy Wanga , BIM Coordinator, Jacobs, Hyderabad , India

From a digital delivery and BIM implementation perspective, I'd like to share a few practical observations relevant to climate resilience use cases in the Asia-Pacific context.

Digital Twin Applications Supporting Climate Decision-Making

In infrastructure and urban projects, Digital Twin approaches are increasingly being used in the following ways:

1) Urban Flood & Stormwater Management

- Integration of BIM + GIS + hydraulic simulation models

- Scenario testing for extreme rainfall events
- Visualizing flood depth impact on transport corridors and utilities
- Supporting early-stage planning decisions (e.g., drainage redesign, retention basins)

2) Transport & Critical Infrastructure

- Linking asset models with climate exposure data (heat stress, inundation risk)
- Lifecycle analysis of materials under extreme temperature scenarios
- Simulation of disruption impacts on mobility networks

3) Energy & Utilities

- Monitoring asset performance under climate stress (transformer overheating, grid vulnerability)
- Digital replicas for predictive maintenance in high-risk coastal zones

In many cases across Asia-Pacific, the most effective twins are not city-wide “mega platforms,” but targeted infrastructure twins focused on specific risks.

Deployment & Scaling Challenges in the Region

From implementation experience, three recurring constraints shape outcomes:

- 1) **Data Maturity.** Many organizations lack structured asset data. Without standardized data environments, scaling is difficult. A Digital Twin built on fragmented data becomes a visualization layer — not a decision system.
- 2) **Institutional Ownership.** Climate resilience spans water, transport,

energy, and urban authorities. Without clear governance ownership, Digital Twins remain pilot initiatives.

3) Human Capacity. The challenge is rarely technology. It's interdisciplinary expertise — combining climate modelling, infrastructure engineering, and digital systems integration.

What Actually Enables Scaling

Based on practical delivery insights:

- 1) Start with a **single high-impact climate risk use case**, not a city-wide ambition;
- 2) Define measurable resilience KPIs (flood downtime reduction, energy reliability improvement);
- 3) Integrate Digital Twin outputs directly into planning and budgeting cycles; and
- 4) Build internal capability — not just external consultants.

Digital Twins for climate resilience must be framed as a **governance and risk management tool**, not a technology showcase.

Closing Thought

In the Asia-Pacific context, where climate exposure is accelerating, the value of Digital Twins lies less in visual sophistication and more in their ability to:

- 1) Support scenario-based decision making;
- 2) Improve inter-agency coordination; and
- 3) Link long-term climate risk with asset lifecycle planning

The shift needed is from “*building a twin*” to “*embedding digital resilience into decision systems.*”

I would be very interested in learning how others in the region are addressing institutional alignment and long-term funding models for these platforms.

3. Md Selim Reza, System Analyst, Ministry of Finance, Bangladesh

Digital Twins as Decision-Support Systems for Climate Resilience

A consistent theme across contributions is that Digital Twins deliver maximum value when embedded in operational and governance systems rather than functioning as standalone dashboards.

Across the Asia-Pacific region, DTs are increasingly used to:

- 1) Support scenario-based climate risk modelling;
- 2) Integrate BIM, GIS, IoT, satellite, and hydraulic datasets;
- 3) Simulate extreme weather events (heatwaves, typhoons, storm surges, flooding);
- 4) Link climate projections with asset lifecycle management; and
- 5) Inform capital investment and retrofit decisions.

Members emphasized that the most effective Digital Twins are often **targeted, sector-specific systems**, rather than city-wide mega platforms.

Sectoral Applications Across the Region

(a) Urban Flood & Stormwater Management:

In **Singapore**, the Virtual Singapore platform evolved into a functional

urban Digital Twin integrating LiDAR-based 3D city models, rainfall radar data, drainage networks, and hydrodynamic simulation tools. Its predictive flood mapping capabilities directly informed pump operations, drainage upgrades, and zoning decisions.

Similarly, municipal-scale Digital Twin systems in the **Republic of Korea** have integrated satellite precipitation forecasts, IoT river-level sensors, and AI-based runoff modelling. By simulating multiple rainfall-return scenarios, authorities improved early-warning systems and pre-emptive infrastructure operations.

Key Insight: Digital Twins are most impactful when connected to real-time operational systems (e.g., sluice gates, pumps) rather than remaining analytical planning tools.

(b) Coastal Protection & Sea-Level Rise:

In **Australia**, coastal Digital Twins have simulated sea-level rise, storm surges, and erosion impacts on transport corridors and port infrastructure. High-resolution bathymetry, satellite altimetry, and AI-enhanced modelling support long-term relocation and adaptation strategies.

In Pacific Island contexts, simplified cloud-based DT frameworks have integrated drone imagery and satellite data to guide ecosystem-based adaptation measures such as mangrove restoration.

Key Insight: Even modular, lower-cost Digital Twin architectures can meaningfully support climate adaptation if designed around clear risk scenarios.

(c) Energy & Infrastructure Resilience:

In **Japan**, smart-grid Digital Twins combine weather forecasts, demand prediction algorithms, and grid asset monitoring to manage heatwave-induced peak loads and reduce blackout risks.

In **India**, pilot Digital Twin initiatives in metro rail, ropeways, townships, and cold storage projects have extended beyond 3D/5D BIM into 6D–9D BIM applications:

6D/7D: Energy modelling for heatwave resilience and cooling system optimization

8D: Disaster and extreme-environment scenario simulations

9D: Lean construction, waste reduction, and embodied carbon minimization

Key Insight: Climate-aligned BIM must extend into operations and maintenance phases to unlock resilience benefits.

What Enables Effective Deployment?

Across case experiences, three enabling dimensions emerged:

1) Data Maturity and Integration:

- Structured asset data environments are foundational;
- Fragmented or siloed datasets reduce DTs to visualization layers rather than decision systems;
- Integration of BIM + GIS + climate models + IoT is essential; and
- Standardized data governance frameworks and cybersecurity protocols are critical before scaling.

2) Institutional Ownership and Governance Alignment:

Digital Twins for climate resilience span multiple sectors—water, transport, energy, urban planning. Without clear institutional ownership:

- Platforms remain pilot projects;

- Budget allocation becomes uncertain; and
- Inter-agency coordination weakens;

Successful cases embedded DTs into national smart city strategies or disaster management authorities, ensuring sustained funding beyond innovation grants.

Members stressed that Digital Twins must be framed as **governance and risk-management tools**, not technology showcases.

3) Human Capacity and Interdisciplinary Expertise:

A recurring constraint across the Asia-Pacific region is the shortage of professionals who can bridge: climate science; infrastructure engineering; data analytics; and digital systems integration.

Over-reliance on external consultants can limit knowledge transfer. Effective approaches include: university–government collaborations, municipal capacity-building programs, and phased sector-based deployment before multi-sector expansion.

4) Financing and Sustainability Models:

Financing experiences reveal that:

- Initial DT systems are often supported by public innovation funds or climate adaptation programs;
- Public–private partnerships reduce upfront capital costs;
- Cloud-based subscription models enable smaller municipalities to access advanced modelling; and
- Multilateral development banks increasingly recognize DTs as climate-risk assessment tools.

However, long-term operational financing remains challenging because benefits are often measured in **avoided losses** rather than direct revenue generation.

Scaling Challenges:

Members identified persistent constraints:

- 1) 80% of BIM use still stops at 5D (costing), limiting lifecycle resilience integration;
- 2) Absence of globally standardized frameworks integrating BIM and Climate Change Technologies beyond project delivery (e.g., ISO 19650 focuses primarily on information management);
- 3) Fragmented data ownership across ministries and agencies;
- 4) Limited alignment between climate modelling timelines and infrastructure budgeting cycles; and
- 5) Scaling requires moving from isolated pilots to institutionalized digital resilience systems.

Strategic Lessons for Asia-Pacific:

Across contributions, several regional lessons stand out:

- 1) Start with a high-impact, clearly defined climate risk use case;
- 2) Define measurable resilience KPIs (e.g., reduced flood downtime, improved energy reliability);
- 3) Embed Digital Twin outputs into planning and capital budgeting processes;
- 4) Invest in institutional alignment before technological sophistication;

- 5) Prioritize modular, cloud-based architectures in resource-constrained contexts;
- 6) Treat Digital Twins as long-term governance infrastructure.

Conclusion:

The Asia-Pacific region is highly climate-exposed and infrastructure-intensive. Digital Twin technologies offer significant potential to:

- 1) Enhance scenario-based climate decision-making;
- 2) Strengthen inter-agency coordination;
- 3) Integrate climate risk into asset lifecycle planning; and
- 4) Reduce disaster losses and improve system reliability.

Yet technology alone is insufficient. The long-term success of Digital Twins for climate action will depend on:

- 1) Institutional embedding;
- 2) Sustainable financing;
- 3) Data governance frameworks; and
- 4) Human capacity development.

4. Rohit Raj , Research Trainee, Plant Science, BITS Pilani

Digital Twin (DT) technologies are increasingly emerging as decision-support systems rather than mere visualization platforms in the Asia-Pacific region. From my professional engagement in climate resilience planning, infrastructure modelling, and interdisciplinary policy consultations, I have observed that successful Digital Twin deployments share three

characteristics: (i) integration of multi-source real-time data, (ii) institutional ownership beyond pilot funding cycles, and (iii) clear linkage to operational decision-making.

Below, I provide situation- and example-based insights drawn from regional experiences.

Digital Twin Applications Supporting Climate Resilience Decision-Making

(a) Urban Flood Management – Singapore and Republic of Korea

In Singapore, the Virtual Singapore platform evolved into a functional urban Digital Twin integrating LiDAR-based 3D city models, drainage sensor networks, rainfall radar data, and hydrodynamic simulation tools. During high-intensity rainfall events, the DT system enabled predictive flood mapping at sub-district resolution. Rather than serving only as a planning tool, it directly informed drainage capacity upgrades, pump station operations, and land-use zoning adjustments in flood-prone zones. Similarly, in the Republic of Korea, municipal-scale Digital Twin flood forecasting systems have been deployed in coastal cities vulnerable to typhoons. By integrating satellite precipitation forecasts, IoT river-level sensors, and AI-based runoff modelling, authorities were able to simulate multiple rainfall-return scenarios (e.g., 50-year and 100-year events). The outputs supported early-warning protocols and pre-emptive gate operations in estuarine barrages. Importantly, this reduced response time and minimized economic losses during extreme events.

Key Lesson: Digital Twins became effective when directly connected to operational control systems (e.g., sluice gates, pumping infrastructure), rather than functioning only as scenario-planning dashboards.

(b) Coastal Protection and Sea-Level Rise – Australia and Pacific Island States

In Australia, Digital Twin applications for coastal cities such as Sydney and

Melbourne have been used to simulate sea-level rise scenarios combined with storm surge modelling. High-resolution bathymetric data, satellite altimetry, and AI-enhanced coastal erosion models enabled infrastructure planners to evaluate long-term relocation strategies for transport corridors and port infrastructure.

In selected Pacific Island contexts, simplified Digital Twin frameworks were developed for coral reef monitoring and shoreline change prediction. While resource constraints limited high-end modelling, cloud-based platforms allowed integration of drone imagery and satellite data to guide ecosystem-based adaptation strategies (e.g., mangrove restoration placement).

Key Lesson: Even resource-limited Digital Twins can meaningfully inform climate adaptation if built on modular and scalable digital architectures.

(c) Energy and Infrastructure Resilience – Japan and India

Japan has advanced the integration of Digital Twins within smart-grid systems to manage heatwave-induced peak loads. By combining weather forecasts, demand prediction algorithms, and grid asset monitoring, utilities simulated stress scenarios and optimized distributed energy storage dispatch. This reduced blackout risks during extreme heat events. In India, pilot Digital Twin initiatives for metro rail systems and urban transport infrastructure have incorporated climate stress testing (flood exposure, heat stress on tracks). Scenario modelling informed drainage retrofits and material resilience upgrades. Although still evolving, these systems demonstrated how infrastructure Digital Twins can bridge climate modelling with asset management planning.

Key Lesson: Sector-specific Digital Twins are most impactful when aligned with asset lifecycle management and capital investment planning.

Policy Frameworks, Financing Approaches, and Institutional Capacity

From experience in policy advisory and cross-sector engagement, three

enabling dimensions have shaped successful deployment:

(a) Policy and Governance Integration

Digital Twin scaling requires institutional embedding within urban planning or disaster management authorities. In Singapore and Korea, DT systems were integrated into national smart city strategies, ensuring sustained budget allocation beyond pilot phases.

A common barrier in developing Asia-Pacific contexts has been fragmented data governance. Ministries responsible for water, transport, and environment often maintain siloed datasets, limiting interoperability. Establishing national data-sharing frameworks and cybersecurity protocols proved essential before technical deployment could scale.

(b) Financing and Public-Private Collaboration

Blended financing models were instrumental. Initial DT platforms were often supported through public innovation grants or climate adaptation funds, while private technology providers contributed through public-private partnerships (PPP).

In some cases, cloud-based subscription models reduced upfront infrastructure costs, enabling smaller municipalities to access advanced modelling capabilities without heavy capital investment. Multilateral development banks increasingly recognize Digital Twins as climate-risk assessment tools eligible under adaptation finance frameworks. However, long-term operational funding remains a challenge when benefits are diffuse and indirect (e.g., avoided disaster losses rather than immediate revenue generation).

(c) Human Expertise and Institutional Capacity

A major constraint across the Asia-Pacific region is not hardware or software, but technical capacity. Digital Twin systems require

interdisciplinary expertise—climate science, data engineering, AI modelling, and urban planning. Where local expertise was limited, over-reliance on external consultants reduced knowledge transfer and sustainability.

Successful cases invested in:

- 1) Capacity-building programs within municipal agencies;
- 2) University–government research collaborations; and
- 3) Open-data training initiatives for public officials

Resource-limited environments benefited from phased deployment—starting with single-sector pilots (e.g., flood management) before expanding to multi-sector Digital Twins.

Concluding Perspective

The Asia-Pacific experience demonstrates that Digital Twins are most transformative when positioned as decision-support ecosystems rather than visualization tools. Their effectiveness depends less on technological sophistication and more on governance integration, institutional ownership, and human capacity development.

For inclusive regional scaling, priority actions should include:

- 1) Standardized data governance frameworks;
- 2) Regional knowledge-sharing platforms to reduce duplication;
- 3) Capacity-building partnerships between universities, governments, and industry; and
- 4) Modular, cloud-based Digital Twin architectures suitable for resource-constrained contexts.

Digital Twin technologies hold substantial promise for strengthening climate resilience in Asia-Pacific cities. However, their long-term impact will depend on aligning technological innovation with institutional reform and

sustainable financing mechanisms.

5. Prasad Deshmukh, BIM Consultant, Neilsoft, India

With over a decade of experience in the BIM field and prior knowledge in Climate Change Technologies, I have observed that while we are already using BIM (Digital Twins), we are not leveraging its full potential—particularly in addressing climate change. However, in several projects, we have begun applying BIM within the climate change context.

With **Metros, Ropeways, Mega Townships & Cold Storage Projects**

We have progressed projects beyond simple 3D/5D models into 6D–9D BIM which try to address climate-related challenges:

- 1) **Energy & Thermal Resilience (6D/7D):** In cold storage and metro projects, we utilize energy modelling to simulate the impact of heatwaves on cooling systems. By developing Digital Twins enriched with historical heatwave data, we simulate energy consumption patterns and predict potential system failures before the design stage.
- 2) **Safety & Disaster Planning (8D):** For ropeways and large townships, we apply 8D BIM to simulate extreme environmental scenarios. These simulations support site selection and feasibility assessment, and guide design retrofits and execution strategies aligned with climate risks.
- 3) **Waste & Carbon Reduction (9D):** Through Lean 9D BIM and modular construction approaches, we have reduced material waste and the carbon footprint of large warehouses and township developments.

Scaling-Up Challenges

Most projects stop at 5D (costing). Approximately 80% of the industry still treats BIM as a static construction tool. For meaningful climate resilience, BIM must be implemented through the operations phase.

1) The Global Standards Gap. There is no ISO-style standard that integrates BIM with Climate Change Technologies. Currently, practices vary widely, limiting scalability. Although ISO 19650 exists, it primarily addresses information management up to project delivery and does not sufficiently cover post-execution BIM implementation for operational climate performance.

2) The Talent Shortage. There is a significant shortage of professionals who understand both construction engineering and climate science, and who can use complex climate data into practical engineering solutions.

6. Ms Cristina Macaraig, Founder/ President of Wired field Philippines, Inc., Philippines

From our experience working with climate resilience systems for local governments in the Philippines, many current Digital Twin implementations are primarily used for visualization and simulation in planning environments. These systems typically integrate geospatial datasets, hazard models, and infrastructure layers to help planners evaluate flood risks, infrastructure exposure, and climate scenarios.

However, these platforms often rely on specialized analytical tools used mainly by technical teams, which can limit their direct use by frontline decision-makers during emergencies.

In practice, we observed a gap between analytical digital twin environments and operational decision-making on the ground. Resource constraints, fragmented institutional data, and limited technical capacity make it difficult for local governments to use complex modelling platforms in real-time response situations.

Our work focuses on bridging this gap by translating environmental signals, infrastructure data, and incident information into operational decision-support tools that can be used by local responders and government agencies.



This approach prioritizes accessibility, interoperability, and practical deployment in resource-constrained environments.

7. Peter Gorm Larsen, Vice-Head of section, Professor at Department of Electrical and Computer Engineering, Aarhus University, Denmark

Dear members,

My team has worked substantially with establishing digital twins for cyber-physical systems and we are just starting to use them for Sustainable Water-based cooling in Megacities (see <https://www.pdjf.dk/en/article/sustainable-water-based-cooling-in-megacities/>). This will start in Singapore but we expect to establish collaboration with others in the Asia-Pacific area.

[Sustainable Water-based cooling in Megacities](#)

[Singapore and Denmark pioneer](#)

8. APCTT INPUT 1

Dear members,

Many thanks for your interesting and informative responses. Here are some points I would like to bring to your notice.

Digital Twins (DT) in climate resilience in the Asia-Pacific region are no longer just isolated models but rather integrated decision support systems. However, there are some gaps in the region, especially in linking global climate scenarios, multi-hazard risks, and social vulnerability to operationalise decisions.

Recent breakthroughs in the development of 'system of systems' and Earth-scale Digital Twins provide insights into using high-resolution climate models with city-level and infrastructure-level Digital Twins. This allows cities to test climate adaptation options (e.g., drainage systems, land use planning, retrofits) under consistent long-term climate scenarios, rather than responding to single events. Therefore, in the Asia-Pacific region, sector-specific Digital Twins (e.g., flood, heat) can utilise standardised regional climate projections to assess the full spectrum of risks.

Currently, there is greater understanding that Digital Twins can tackle various climate-related hazards and cross-sector systems, including water, energy, transportation, and coastal zones. This is because the risk of climate-related disasters tends to cascade, especially in megacities and small island states.

Another shift in the development of Digital Twins in the Asia-Pacific region is the need to incorporate 'with and for humans' Approach. DTs integrating social vulnerability and participatory decision support should be able to compare options such as grey infrastructure (e.g., levees) and nature-based solutions (e.g., mangroves, green corridors, cooling centres) not only in terms of risk mitigation but also in terms of equity.

Additionally, I feel that the scaling up of Digital Twins is more an institutional and financial issue than a technological one. Evidence suggests that DTs need to be seen as part of a broader “digital climate risk infrastructure,” moving beyond pilot projects to full-fledged governance, validation, and public accountability systems. Governments should seek to advance the uptake of Digital Twins by ensuring that DT outputs are used to inform planning tools such as environmental impact assessments, building codes, zoning laws, and public investment plans, with clear definitions on data ownership, management, and updates.

Finally, Digital Twins can be positioned as a new form of digital public infrastructure providing standardised risk metrics, scenario analyses, and monitoring data justify resilient design choices and quantifying avoidable

losses for blended finance. This would require structured “DT-readiness” pathways to build geospatial and climate-risk literacy, integration skills, and cross-disciplinary expertise within local and national institutions.

Thank you

References

1. Zhu, M., & Jin, J. (2025). Data-driven urban digital twins and critical infrastructure under climate change: A review of frameworks and applications. *Urban Planning*, 10(3).
2. Ali, E., & Mansour, A. (2025). Digital twin for climate resilience: Transforming smart cities for a sustainable future. *ISPRS Archives XLVIII-G-2025*, 139–146.
3. Bauer, P. et al. (2024). Digital twins of the Earth with and for humans. *Communications Earth & Environment*, 5, 343.
4. Tan, B. et al. (2024). Assessing governance implications of city digital twin technology. *Urban Analytics Lab / TFSC Digital Twin Maturity Study*.
5. Satria, A. et al. (2025). Integrating local knowledge and governance for effective climate resilience. 3(2), 45–60.
6. United Nations Development Programme (2025). Closing the finance gap: New routes to climate resilience in Asia-Pacific.
7. International Monetary Fund (2024). *Unlocking Climate Finance in Asia Pacific: Transitioning to a Resilient Future* (Departmental Paper).

9. APCTT Input 2

Just wanted to share one more famous case from Singapore:

Grid Digital Twin for Energy Resilience

The Energy Market Authority (EMA) and **SP Group** have implemented a **Grid Digital Twin** to manage the increasing volatility of the energy sector driven by climate change and the transition to renewables.

- This DT consists of two layers: an **Asset Twin** for monitoring the health of physical infrastructure (transformers, cables) and a **Network Twin** for simulating power flow. As extreme heatwaves drive up cooling demand, the twin predicts grid stress points, allowing for proactive maintenance and preventing localized blackouts.

- To meet climate targets, Singapore is rapidly scaling solar energy and EV charging. The Digital Twin acts as a **Virtual Power Plant (VPP)**, simulating the impact of intermittent renewable sources on the grid. This ensures that even during adverse weather conditions, the energy system remains stable and resilient.

Many thanks to all who contributed to this query!

This Consolidated Reply is a systematic compilation of all responses received and additional desk research. If you have further information to share on this topic, please send it at apctt@un.org.

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