Climate resilience with advanced data analytics

Collecting and analysing historical and real-time data is valuable in predicting climate resilience, enabling project stakeholders to make the right decisions.

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From floods and fires to storms and droughts, more frequent and severe climate events are challenging the resilience and adaptability of our built environment. These disasters also place greater pressure on infrastructure to perform under changing conditions. The question is no longer if we should respond but how we can respond smarter.

Digital technologies – especially those that capture, analyse and draw insights from large volumes of data – are becoming increasingly essential to enable climate resilience. They support a more dynamic, data-driven approach to decision making across the asset life cycle – one that is not just reactive but also predictive, preventive and adaptive.

Digital technologies as catalysts

Climate-resilient construction goes beyond meeting compliance requirements – it's more about proactively preparing for, responding to and recovering from climate-related disruptions. As climate risks become more frequent and complex, digital technologies offer a practical pathway to resilience – one built on data, enabled by technology and guided by smart insights.

Different technologies play different roles in this process. Internet of Things (IoT) sensors and cloud platforms help collect and store vast amounts of data. Data wrangling and big data support the cleaning and processing of that data, while artificial intelligence (AI), machine learning and business intelligence platforms analyse patterns and turn insights into smarter, more targeted decisions.

By analysing past events, monitoring current conditions, simulating future scenarios and identifying vulnerabilities, these tools support three key types of analytics that underpin climate resilience:

- Predictive analytics use historical and real-time data to forecast risks and assess their likely impacts on buildings and infrastructure.
- Preventive analytics detect early warning signs and guide timely interventions to reduce the chance of failure and avoid costly damage.
- Adaptive analytics enable systems and structures to adjust over time, responding flexibly to new and evolving climate conditions.

Landscape of data in construction – historical and real-time

A key part of building climate resilience is understanding the environment in which the project operates – and that starts with data. Today's construction projects generate more data than ever before, much of which is directly relevant to managing climate-related risks. Such data generally falls into two categories – historical data and real-time data:

- Historical data includes past weather and climate records (rainfall intensity, flood frequency, extreme temperatures), energy use, material wear and tear and failure or maintenance reports from buildings and infrastructure. These datasets help establish baseline risk levels, identify long-term trends and support decisions on what, where and how to build more resiliently.
- Real-time data is gathered through IoT sensors that measure temperature, humidity, structural stress and ground movement; smart tracking devices that monitor site activity and workforce conditions; and drones and satellite imagery that capture live images of site and environmental conditions. This live data provides up-to-date visibility into site conditions and structural behaviour under changing circumstances.

Bringing together both types of data creates a fuller, more dynamic view of climate risks and how systems perform over time. Digital technologies make this possible by collecting, integrating and presenting data from multiple sources to enable more localised, accurate and context-aware decisions.

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Advanced technologies such as building information modelling (BIM), AI-powered analytics platforms and digital twins enable stakeholders to make decisions that are not only reactive but also predictive (such as predicting landslide risks from rainfall data), preventive (such as modifying material selection to suit projected temperature shifts) and adaptive (such as optimising construction sequences in response to changing ground conditions).

Role of analytics in smarter decision making

Data alone doesn't build resilience – it's the insights that lead to action that make the difference. That's where analytics comes in. By applying algorithms, models and visual tools, data analytics technologies help project teams make sense of complex information and act on it.

Here's a real-world example of preventive analytics in action. Along a 25 km stretch of the North Island Main Trunk line, WSP New Zealand and KiwiRail have installed a real-time geotechnical monitoring system to improve climate resilience on slip-prone rail infrastructure. The system collects and analyses data from cameras, rain gauges and slope and debris sensors to monitor ground conditions in real time. It sends alerts and high-frequency imaging when thresholds are crossed, usually during severe weather, enabling KiwiRail to respond quickly and avoid delays, derailments and expensive damage.

In this case, digital technologies work together to:

- collect data from sensors and external sources
- store and process the data through cloud-based platforms
- analyse patterns and identify early warning signs of potential environmental hazards
- trigger action through real-time alerts and dashboards.

This seamless flow from data to insight then to timely response demonstrates how data-enabled preventive analytics reduce infrastructure vulnerability to climate-induced disasters.

Beyond individual events, analytics also support long-term planning activities such as climate risk assessments, asset prioritisation and carbon emissions tracking. These insights can be integrated into digital twins or BIM models to test different design options and understand how design choices affect long-term resilience.

In all these cases, analytics bridge the gap between information and action. It helps engineering and construction teams to:

- prioritise climate risks based on likelihood and impact
- optimise designs and construction methods for future conditions
- reduce life cycle costs by preventing failures and enabling quicker recovery.

Enabling systemic change

More projects are now trialling digital technologies to improve climate resilience, but the real opportunity lies in scaling these solutions across projects. This shift isn't just about adopting new tools – it also requires changes in how organisations, policies and systems work together.

Across Aotearoa, we're seeing encouraging progress. For example, Auckland's Safeswim platform uses real-time data to forecast water quality at city beaches, while Wellington's digital twin helps communities visualise flooding and sea-level rise scenarios.

These city-wide digital twins are complemented by national platforms such as NIWA DataHub, which provides real-time climate information. Together, they demonstrate how digital technologies turn data into knowledge, then insights into timely actions. Governments, agencies and industry leaders increasingly expect infrastructure investments to demonstrate long-term resilience.

Shared digital platforms

Of course, challenges remain. Many organisations still face limited access to reliable data, a lack of shared standards and gaps in digital capability. But data intelligence is strengthening collaboration across the board. With shared digital platforms and scalable analytical capacities, engineers, architects, planners and policy makers can access the same information, exchange insights and coordinate their actions.

This breaks down silos and supports faster, more informed decisions. Importantly, these technologies are now becoming more accessible across firms with varying business sizes. New Zealand's Digital Boost initiative offers free online resources and training to help small and mid-sized firms benefit from data-driven insights through cloud-based tools and user-friendly interfaces without the need for dedicated in-house data teams.