



# Safe, Sustainable and Resilient Infrastructure

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Digitalization as Accelerator

Tapan Mozumdar



GLOBAL  
NETWORK  
for ZERO

# What is Digitalization?

**Digitalization** refers to the integration of digital technologies into everyday processes, systems, and services to improve efficiency, accessibility, and decision-making.

It goes **beyond just converting analog data to digital form (digitization)**—digitalization **transforms** how organizations operate and deliver value.

## Examples include:

- Using IoT sensors to monitor infrastructure health.
- Implementing AI for predictive maintenance.
- Leveraging cloud platforms for real-time collaboration.



# Process Transformation

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## Misunderstood as Digitalization

## Why It's Not

Scanning paper documents

It's digitization, not transformation.

Using Excel for data entry

It's manual digital work, not automated or intelligent.

Installing computers or internet

It's infrastructure, not process innovation.

Basic automation without analytics

Lacks adaptive intelligence or integration.

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**Digitalization must change how things are done**, not just make them digital.



# Benefits of Digitalization

## Strategic Benefits:

**Efficiency:** Streamlined workflows and reduced manual effort.

**Transparency:** Real-time data visibility and accountability.

**Resilience:** Predictive analytics for risk mitigation.

**Sustainability:** Optimized resource use and emissions tracking.

**Inclusivity:** Broader access to services via digital platforms.

## Examples from infrastructure:

BIM enables low-carbon design.

GIS helps climate-resilient site selection.

Digital twins simulate stress scenarios for proactive planning.



# Challenges with Digitalization

## Key Challenges:

- **Data privacy and cybersecurity** risks.
- **Digital divide:** Unequal access to tools and connectivity.
- **Interoperability:** Difficulty integrating across platforms.
- **Skill gaps:** Lack of trained personnel.
- **High upfront costs:** Especially for small municipalities or rural areas.

## Mitigation strategies include:

- Open standards (e.g., OpenBIM).
- Capacity building and training.
- Public-private partnerships.



# Importance of Digitalization

For a growing country like **India**, digitalization is vital to:

- **Scale infrastructure efficiently** across diverse geographies.
- **Achieve Net Zero by 2070** through smart energy and transport systems.
- **Bridge urban-rural gaps** using remote monitoring and mobile platforms.
- **Enable climate resilience** in flood-prone and drought-hit regions.
- **Support inclusive development** via e-governance and digital public services.

**PM Gati Shakti** is a prime example—using GIS and cloud platforms to coordinate multi-modal infrastructure development.



# Lifecycle Digitalization

Phase	Tools	Purpose
<b>Design</b>	BIM (Autodesk Revit, Bentley), GIS (ArcGIS, QGIS)	3D modeling, site analysis
<b>Construction</b>	IoT (Bosch, AWS), Drones (DJI), Construction Cloud	Real-time tracking, safety
<b>Operation</b>	Digital Twins (Bentley iTwin), Smart Asset Management (IBM Maximo)	Predictive maintenance
<b>Monitoring &amp; Reporting</b>	Carbon Accounting (Microsoft Sustainability Manager, Persefoni)	Emissions tracking
<b>Planning &amp; Coordination</b>	Gati Shakti Platform, MEGHRAJ Cloud	Integrated infrastructure planning

# Safety

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# Monitoring to warn in advance

## Real-Time Monitoring and Alerts

- IoT sensors embedded in infrastructure (e.g., bridges, tunnels, pipelines) can continuously monitor stress, temperature, vibration, and other parameters.
  - The I-35W Saint Anthony Falls Bridge in Minnesota uses embedded sensors to monitor strain, temperature, and vibrations in real time.
  - Smart water grids in Singapore detect pressure drops and leaks instantly, preventing water loss and infrastructure damage.
- Data is transmitted in real time to centralized systems, allowing for early detection of anomalies or potential failures.
- Automated alerts can trigger preventive actions before a hazard escalates.

## Predictive Maintenance

- Using AI and machine learning, historical and real-time data can be analyzed to predict when components are likely to fail.
  - Deutsche Bahn (German Railways) uses AI to predict failures in train components, reducing delays and improving safety.
  - GE's Predix platform helps power plants anticipate turbine failures using sensor data and machine learning.
- This shifts maintenance from reactive to proactive, reducing the risk of sudden breakdowns or accidents.



# Simulations for decisions in advance

## Digital Twins

- A digital twin is a virtual replica of a physical asset or system.
- It allows engineers to simulate stress tests, environmental impacts, and usage scenarios without touching the actual infrastructure.
  - City of Shanghai developed a digital twin of its urban infrastructure to simulate traffic, pollution, and disaster scenarios.
  - Siemens uses digital twins for factory floors to test safety protocols and optimize layouts before physical implementation.
- This helps in risk assessment, planning upgrades, and validating safety measures.

## Enhanced Decision-Making

- Integrated platforms can combine data from multiple sources (e.g., weather, traffic, structural health) to support data-driven decisions.
  - Smart traffic systems in Stockholm use real-time data to reroute traffic and reduce accident-prone congestion.
- During a flood, digital systems can guide evacuation routes based on real-time road conditions and infrastructure integrity.
  - FloodNet in New York City integrates rainfall data and sewer capacity to guide emergency responses during storms.



# Compliances and Inspections

## Regulatory Compliance and Auditing

- Digital records of inspections, maintenance, and sensor data ensure transparency and traceability.
  - Building Information Modeling (BIM) in the UK is mandated for public infrastructure projects to ensure compliance and traceability.
- Authorities can audit infrastructure safety more efficiently and enforce compliance with safety standards.
  - Digital inspection logs in oil refineries help meet safety regulations and reduce manual errors.

## Remote Inspections and Drones

- Drones and robotic systems can inspect hard-to-reach areas like high-rise buildings, bridges, or underground tunnels.
  - Indian Railways uses drones to inspect bridges and tracks in remote areas, improving safety without human risk.
  - Inspecting wind turbines via drones in Europe allows detection of blade cracks and wear without climbing.
- Combined with AI image analysis, they can detect cracks, corrosion, or structural weaknesses without risking human lives.



# Cyber-Physical Security

## **Intrusion Detection and Response**

Digital systems can detect unauthorized access attempts in real time using AI-based intrusion detection systems (IDS). The U.S. Department of Homeland Security uses AI to monitor and respond to cyber threats targeting water treatment and power plants.

## **Network Segmentation and Access Control**

Infrastructure networks are segmented digitally to isolate critical systems (e.g., SCADA) from public-facing networks. European energy utilities implement strict access controls and network segmentation to protect grid operations from ransomware attacks.

## **Threat Simulation and Penetration Testing**

Digital twins and simulation tools are used to test how infrastructure would respond to cyberattacks without risking real systems. Singapore's Cybersecurity Agency runs simulated attacks on smart city infrastructure to identify vulnerabilities.

## **Blockchain for Data Integrity**

Blockchain technology ensures that sensor data and logs are tamper-proof, which is critical for forensic analysis after a cyber incident. Dubai's smart city initiative uses blockchain to secure infrastructure data and ensure transparency.

## **AI-Powered Anomaly Detection**

Machine learning models analyze patterns in network traffic and system behavior to detect subtle anomalies that may indicate a breach. Israel's national water authority uses AI to detect unusual patterns in water flow and control systems, flagging potential cyber intrusions.

## **Incident Response Automation**

Automated systems can isolate affected components, shut down compromised systems, and alert operators instantly. Smart grid operators in the U.S. use automated response systems to contain cyberattacks and prevent cascading failures.





# Sustainability

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# Digital Tools in Design Phase

## Building Information Modelling (BIM)

**Purpose:** 3D modelling and simulation of infrastructure assets.

**GHG Impact:** Enables energy-efficient design, material optimization, and lifecycle carbon analysis.

**Tools:** Autodesk Revit, Bentley OpenBuildings, Trimble Tekla.

## Digital Twins

**Purpose:** Virtual replicas of infrastructure systems for performance simulation and tracking.

**GHG Impact:** Predicts energy use, climate stress response, and carbon footprint.

**Tools:** Siemens NX, Bentley iTwin, Dassault Systèmes 3DEXPERIENCE.

## Geospatial and Remote Sensing Platforms

**Purpose:** Site selection, environmental impact assessment, and resource mapping.

**GHG Impact:** Supports nature-based solutions and low-carbon siting.

**Tools:** ESRI ArcGIS, Google Earth Engine, QGIS.



# Digital Tools in Construction Phase

## Construction Management Platforms

**Purpose:** Real-time tracking of materials, labor, and emissions.

**GHG Impact:** Reduces waste, optimizes logistics, and monitors embodied carbon.

**Tools:** Procore, Oracle Primavera, Autodesk Construction Cloud.

## IoT and Sensor Networks

**Purpose:** Monitor equipment usage, fuel consumption, and site conditions.

**GHG Impact:** Enables low-emission machinery scheduling and energy-efficient operations.

**Tools:** Bosch IoT Suite, AWS IoT, Schneider Electric EcoStruxure.

## Drone and Robotics Integration

**Purpose:** Site surveying, progress tracking, and safety inspections.

**GHG Impact:** Reduces manual travel and improves precision in resource use.

**Tools:** DJI Enterprise, Hexagon Leica Geosystems, DroneDeploy.



# Digital Tools in Operation Phase

## Smart Asset Management Systems

**Purpose:** Predictive maintenance, energy monitoring, and fault detection.

**GHG Impact:** Extends asset life, reduces downtime, and lowers operational emissions.

**Example Tools:** IBM Maximo, SAP Intelligent Asset Management, ABB Ability.

## Energy Management Platforms

**Purpose:** Real-time energy tracking and optimization.

**GHG Impact:** Reduces operational carbon footprint and integrates renewables.

**Example Tools:** Schneider Electric EcoStruxure, Siemens Desigo CC, Honeywell Forge.

## Carbon Accounting and Reporting Tools

**Purpose:** Track Scope 1, 2, and 3 emissions across infrastructure lifecycle.

**GHG Impact:** Enables transparent reporting and compliance with climate goals.

**Example Tools:** Microsoft Sustainability Manager, Salesforce Net Zero Cloud, Persefoni.



# Transport Infrastructure

## Digital Strategies for GHG Reduction

- **Smart Traffic Management:** AI and IoT reduce congestion and idle emissions.
- **Digital Twins for Fleet Optimization:** Simulate routes and vehicle performance.
- **Electrification Planning:** GIS and data analytics identify optimal EV charging locations.
- **Modal Shift Enablement:** Digital platforms promote public and non-motorized transport.

## Case Study: Stockholm's Smart Mobility System

- Integrated traffic sensors and AI to manage congestion.
- Result: 20% reduction in traffic-related emissions and improved air quality.

## Case Study: India's National EV Dashboard

- Tracks EV adoption, charging infrastructure, and emissions avoided.
- Result: Data-driven policy support for low-carbon transport expansion.



# Energy Infrastructure

## Digital Strategies for GHG Reduction and Removal

- **Smart Grids** and Demand Response: Balance renewable inputs and reduce fossil reliance.
- **AI for Load Forecasting**: Optimize generation and reduce overproduction.
- **Blockchain for Carbon Accounting**: Track emissions and offsets transparently.
- **Digital Platforms for Carbon Capture**: Monitor and optimize CCS systems.

## Case Study: UK's National Grid ESO

- Uses AI and digital twins to forecast demand and integrate renewables.
- Result: Enabled zero-carbon operation for multiple hours in 2023.

## Case Study: **Microsoft's Carbon Removal Dashboard**

- Tracks carbon removal purchases and project performance.
- Result: Transparent reporting and acceleration of carbon removal markets.



# Water Infrastructure

## Digital Strategies for GHG Reduction

- **Leak Detection and Pressure Optimization:** Reduce energy use in pumping.
- **Smart Irrigation Systems:** Minimize water and energy waste in agriculture.
- **Wastewater Treatment Monitoring:** Optimize biogas recovery and emissions control.
- **Nature-Based Solutions Mapping:** Use GIS to plan wetlands and green buffers.

## Case Study: Cape Town's Water Efficiency Program

- Digital dashboards and predictive analytics guided water conservation.
- Result: Reduced water-related energy use and associated emissions.

## Case Study: Colombia's Smart Water Distribution

- Digital modeling reduced water loss and pumping inefficiencies.
- Result: Lowered operational emissions and improved service reliability.



# Cross-Cutting Benefits

- **GHG Reduction:** Direct emissions cuts through efficiency and electrification.
- **GHG Removal:** Support for nature-based and engineered carbon removal.
- **Transparency:** Real-time data for emissions tracking and reporting.
- **Resilience:** Infrastructure adapts to climate risks while reducing emissions.
- **Scalability:** Digital tools can be replicated across regions and sectors.

Digitalization is a strategic enabler of low-carbon infrastructure. By tailoring digital strategies to sector-specific needs, governments and organizations can accelerate GHG emission reduction and removal. The integration of smart technologies, data platforms, and predictive tools ensures that infrastructure not only supports development but also drives climate action.



# Resilience

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# Standing up to climate change

- Climate-resilient infrastructure is designed to withstand, adapt to, and recover from climate-related shocks such as floods, heatwaves, droughts, and rising sea levels.
- Digitalization—through technologies like digital twins, IoT, AI, and big data—plays a transformative role in enhancing the resilience of infrastructure systems.
- It enables predictive modelling, real-time monitoring, and adaptive management, making infrastructure smarter and more responsive to climate risks.



# Awareness and early action

- **Risk Assessment and Predictive Modelling**

- Digital tools simulate climate scenarios and assess vulnerabilities.
- AI models predict infrastructure stress points under extreme conditions.

- **Real-Time Monitoring and Early Warning Systems**

- IoT sensors track environmental parameters (e.g., temperature, water levels).
- Cloud-based platforms issue alerts for floods, storms, or heatwaves.

- **Digital Twins and Virtual Simulation**

- Create virtual replicas of infrastructure assets to test resilience strategies.
- Enable scenario planning and emergency response simulations.



# Sustaining for good

- **Smart Asset Management**

- Data-driven maintenance schedules reduce downtime and extend asset life.
- Remote diagnostics and automated repairs improve operational continuity.

- **Community Engagement and Decision Support**

- Digital platforms facilitate participatory planning and feedback.
- Visualization tools help stakeholders understand climate risks and solutions.



# Smart Cities and Infrastructure

- **Digital twins** and **model predictive control** allow for real-time simulation and optimization of energy systems.
- **AI-driven fault diagnosis** improves reliability and reduces downtime in renewable energy systems.
- **Enterprise-wide optimization** helps industries manage energy consumption across facilities.
- IoT sensors monitor air quality, traffic, and energy usage.
- Data-driven urban planning supports low-carbon transport and building systems.
- Singapore's Smart Nation initiative integrates digital technologies across transport, energy, and urban planning.
  - The city uses IoT sensors and AI to manage traffic flow, reduce energy consumption in buildings, and optimize public transport routes, contributing to its net-zero ambitions.
- **Digitalization is not just a tool but a strategic enabler of net-zero infrastructure.**
  - By embedding intelligence into systems, it allows for proactive, adaptive, and efficient responses to environmental challenges.
  - Governments, industries, and communities must collaborate to harness its full potential while addressing associated risks



# Case Studies

## Water Loss Reduction in Colombia

- In drought-hit regions of Colombia, digital modelling helped optimize water distribution:
  - High-tech models identified leak points and inefficiencies.
  - Result: Significant reduction in water loss and improved supply reliability.

## University Campus Sustainability – Lithuania

- A university in Lithuania used digital twins to:
  - Monitor energy usage and optimize building performance.
  - Simulate climate impacts and retrofit infrastructure accordingly.
  - Result: Improved sustainability and reduced carbon footprint.



# Benefits of Digitalization

- **Proactive Risk Management:** Anticipate and mitigate climate threats before they occur.
- **Cost Efficiency:** Reduce repair and recovery costs through predictive maintenance.
- **Scalability:** Apply solutions across regions and sectors with minimal physical intervention.
- **Inclusivity:** Empower communities with data and decision-making tools.

To conclude:

- Digitalization is a cornerstone of climate-resilient infrastructure.
- By embedding intelligence into physical systems, it enables infrastructure to adapt dynamically to changing climate conditions.
- Governments, engineers, and communities must collaborate to scale digital solutions, ensuring that infrastructure not only survives but thrives in a climate-challenged world.



# Net Zero

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# Call to Action: Building Net Zero

To meet India's Net Zero Emission target by 2070 and contribute to the global goal of limiting warming to 1.5°C, we must reimagine infrastructure as a climate solution—designed, built, and operated using digital intelligence.

Policymakers, industry leaders, technologists, and communities to:

- Embed Digitalization in Infrastructure Policy and Planning
- Accelerate Sector-Specific Digital Strategies
- Invest in Capacity Building and Innovation
- Ensure Equity and Inclusivity
- Monitor, Report, and Improve

Together, we can build infrastructure that not only connects people and economies—but also protects the planet.



# Digitalization: Enabling Net-Zero and Resilient Infrastructure

- **Optimized Energy Production & Distribution:** Real-time data and smart grids precisely balance energy, minimizing waste and emissions from generation to consumption.
- **Accelerated Renewable Energy Integration:** Digital tools accurately forecast and manage variable renewables, seamlessly integrating them into the grid and reducing fossil fuel reliance.
- **Enhanced Energy Efficiency:** Smart systems in buildings and industries pinpoint and optimize energy use, leading to significant reductions in consumption and carbon footprint.
- **Predictive Maintenance:** IoT and AI predict equipment failures, extending asset life, ensuring reliable energy supply, and cutting resource-intensive emergency repairs.
- **Smart Water Management:** Digital monitoring detects leaks and optimizes water usage across networks, crucial for conserving this vital resource and reducing waste.
- **Waste Reduction & Circular Economy:** Digitalization streamlines waste management, from smart collection to material tracking, promoting reuse and minimizing landfill waste.
- **Enhanced Grid Resilience & Cybersecurity:** Advanced digital tools provide robust defense against cyber threats and enable faster recovery from disruptions, ensuring a secure and stable energy future.



# Net Zero by GNFZ

- **Net Zero Energy Certification:** Achieving a balance where the amount of renewable energy produced on-site or procured equals the total energy consumed for design, construction, and operation.
- **Net Zero Emissions Certification:** Eliminating all Scope 1, 2, and 3 greenhouse gas emissions from the design, construction, and operational phases through reduction, permanent removal strategies, or offsets.
- **Net Zero Waste Certification:** Diverting 99% or more of waste from landfills during design, construction, and operation through reduction, reuse, recycling, and composting strategies.
- **Net Zero Water Certification:** Balancing total annual water consumption with on-site captured or recycled water, minimizing reliance on potable water for design, construction, and operation.



# GNFZ Platform

- GNFZ provides an "efficient digital platform" specifically designed to simplify the complex process of tracking and certifying progress towards net zero.
- This platform is characterized as both "powerful" and "user-friendly," facilitating ease of use for organizations of all sizes.
- A key benefit of this digital infrastructure is its ability to keep data "always up to date without the need for countries to spend resources on collecting it themselves," significantly reducing the manual burden of data collection and aggregation.
- The platform serves as a "reliable, simple and measurable tool to trace clear routes to Net Zero in projects and portfolios," providing a centralized hub for all environmental performance data and progress tracking.





Thanks for your attention!