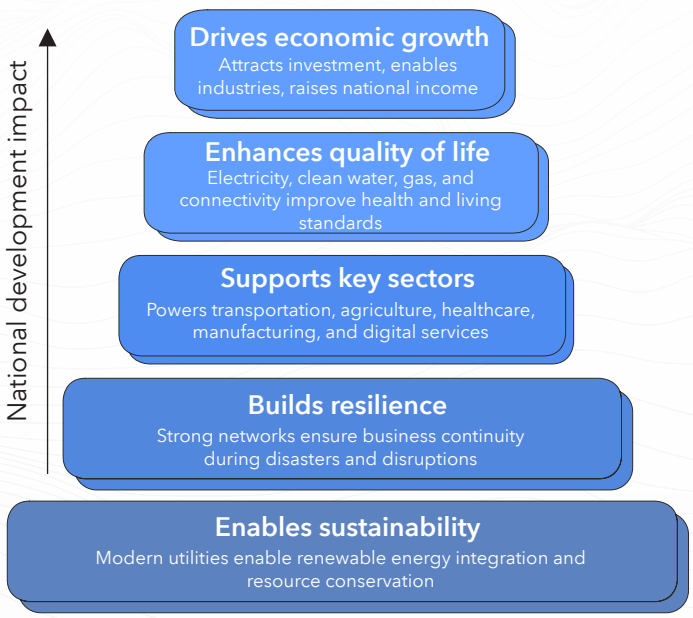
GIS: The Backbone of Smarter Utilities

Utility systems are not support systems; they are national lifelines. Electricity powers everything. Water sustains cities. Gas fuels industries. Telecom connects economies. Together, these utilities form the operational nervous system of nations.

Countries that invest in reliable utility infrastructure consistently demonstrate higher GDP growth, greater industrial productivity, improved public health, stronger disaster resilience, and faster urban development. Utilities typically account for 40–45% of infrastructure investments, and 60–70% of operational dependency across industries.



Utility systems – a national development pyramid

The Cost of Inadequate Utility Systems

This clearly indicates the importance of efficient utility systems. Without reliable utilities, industrialization slows, and public services degrade. Utility inefficiencies also lead to massive economic leakage. For instance, power outages cost industries **₹2.25 lakh crore annually**, water leakage losses reach **40–50% in urban networks,** non-revenue water losses exceed **₹60,000 crore annually,** telecom downtime causes major losses in digital service delivery, and gas distribution inefficiencies increase safety risks and operational costs.

Additionally, the growing population is putting immense pressure on the existing utility systems. India's population is expected to reach **1.6 billion by 2047,** the urban population is projected to exceed **600 million by 2036,** the **energy demand is expected to triple by 2040,** water demand to increase by **2× by 2030,** and telecom data usage is increasing at **~30% CAGR.** These pressures demand **massive utility scaling.** Without modernization, traditional infrastructure models will not sustain future demand.

India's vision of Viksit Bharat@2047 depends on **strong, integrated, technology-enabled utility networks.** Legacy infrastructure approaches cannot meet these demands. Modernization is no longer optional. It is **strategically essential.**

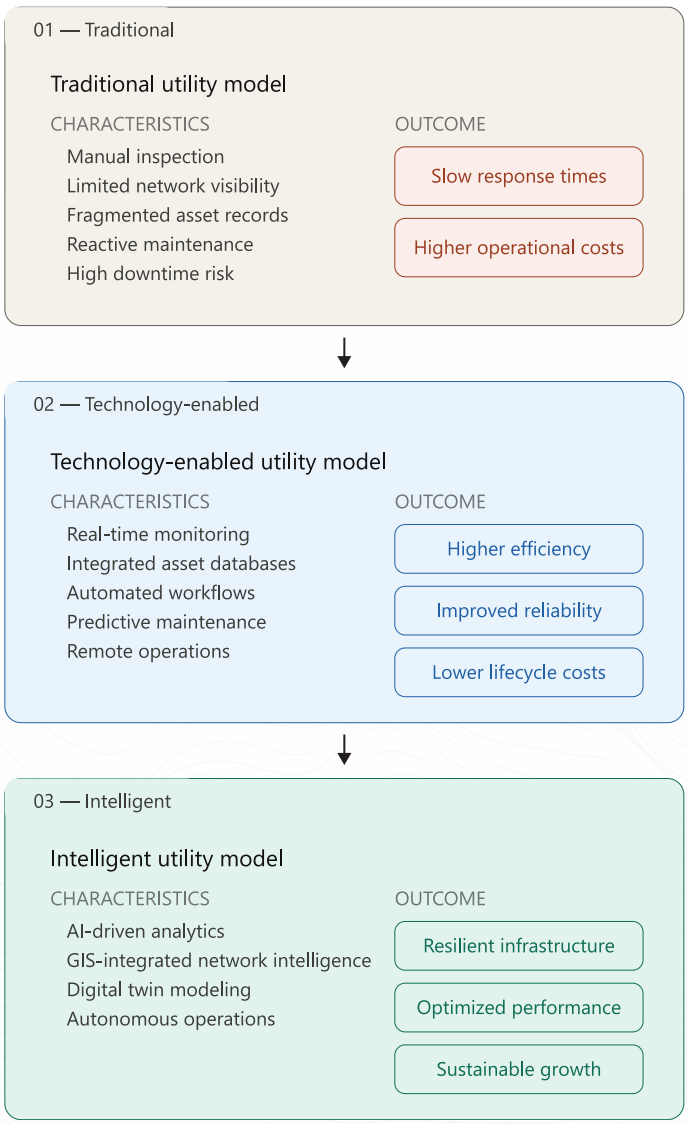
The answer lies in making the utility infrastructure smarter and more efficient using technologies GIS, GeoAI, & Digital Twin.

Why We Need Technology-Enabled Utilities

Traditional utilities are no longer sufficient. Modern economies demand **technology-enabled utility ecosystems** capable of operating intelligently, predicting failures, and responding in real time.

Technology-enabled utilities facilitate real-time

visibility, predictive maintenance, automated response, and integrated operations. This **transition to smarter utilities** is driven by technologies such as Geographic Information Systems (GIS), GeoAI, and Digital twins. With increased automation, better accuracy, and real-time information, these technologies are helping utilities to improve productivity, efficiency, safety, compliance, and reliability. They are transforming utility operations by enabling intelligent asset management, predictive maintenance, and service optimization. With AI-powered GIS, utilities can manage utility infrastructure more effectively, predict equipment failures, optimize service delivery, and generate insights that support better energy and utility operations.



From traditional utilities to digital utilities

Power Utilities

Electricity networks form the **foundation of modern infrastructure,** supporting every sector from manufacturing to healthcare. However, power demand is growing rapidly. Electricity demand is expected to grow **2.5–3× by 2040,** renewable energy is expected to exceed **500 GW capacity,** smart meter installations is projected to exceed **250 million units.** The peak demand of electricity is expected to cross **400 GW by 2030.**

Using GIS, power utilities can manage this rising demand in a better way. By integrating operational data with location intelligence, electric utilities can perform network planning, asset tracking, predictive maintenance, and outage management on a unified platform. With platforms such as Esri's **ArcGIS,** utilities can build a comprehensive system of record and engagement, improving visibility, accelerating project timelines, and enabling more informed, data-driven decisions. Organizations like Adani Electricity Mumbai Limited (AEML), BSES, and TPCODL are using GIS solutions to achieve unmatched efficiency in network planning, outage management, customer service, and more.

When integrated with smart meters, sensors, and SCADA systems, GIS allows utilities to monitor grid performance, optimize maintenance, and respond faster to disruptions. With increasing climate risks, GIS can also help utilities assess vulnerabilities, simulate the impact of extreme events, and strengthen grid resilience.

With advanced tools such as the **Network Information Management System** and **ArcGIS Utility Network,** electric utilities can efficiently manage all the complexities of a modern network.

Adani Electricity Mumbai Limited Optimizes Outage Management with ArcGIS

Quicker & effective response to the customer's power outages in today's ever-changing environment is key to achieving AEML's primary goal of enhanced customer satisfaction. To enable this AEML's Mumbai Distribution Business has implemented an Enterprise GIS solution developed by Esri India. The GIS-based Outage Management System (OMS) has replaced its legacy application, a call-based Complaint Management System (CMS).

The Enterprise GIS solution is aimed to minimize average complaint management time by focusing on network abnormalities rather than customer calls thus improving the overall reliability of the electric system. The system determines the "most probable" location of fault that has taken place in the field on receipt of power outage complaints. With the accurate knowledge of outages & associated up-to-date distribution networks, dispatching outage crew & carrying out the field operations is improved.

"With the Implementation of GIS, we could achieve a single window concept for viewing assets spread across geographical extents. With the help of COTS functionalities available through the product like Electrical Network Tracing, we could derive Consumers connected to DT/Feeder and vice versa. *The software is easy to learn and comes with a whole range of plug-ins for specific needs.*" - **Anand Kumar S V, Addl. VP** – IT DevSecOps, Adani Electricity Mumbai Limited.

Water Utilities

Water utilities today face a growing paradox: while demand for water continues to rise due to urbanization, industrial growth, and population expansion, available water supply is becoming increasingly constrained. **Urban water systems are under pressure from aging pipeline infrastructure, high leakage rates, pressure imbalances, and incomplete visibility of underground assets. In India, these challenges are particularly severe, with Non-Revenue Water (NRW) losses estimated at nearly 40–50%,** meaning a significant portion of treated water never reaches consumers. At the same time, pipeline networks are expanding rapidly across urban areas, and overall water demand is expected to double by 2030. Increasing groundwater depletion is also forcing cities to depend more heavily on managed water supply systems.

To address these challenges, modern water utilities are adopting technology-enabled solutions such as smart sensors, pressure monitoring systems, leak detection technologies, and GIS-based network management platforms. **These technologies allow utilities to detect leaks faster, optimize pressure zones, reduce water losses, and improve the reliability and efficiency of water supply services.** Geospatial intelligence and real-time monitoring are becoming essential for sustainable water management and efficient utility operations.

Gas Utilities

Gas distribution systems present unique operational and safety challenges because even small leaks can lead to serious consequences, including fire hazards, environmental risks, and public safety incidents. **As urban gas infrastructure expands rapidly, ensuring the safe and efficient operation of gas networks has become increasingly critical.** In India, the expansion of PNG (Piped Natural Gas) connections across major cities and the rapid growth of CGD (City Gas Distribution) coverage are driving the development of thousands of kilometers of new pipeline networks every year.

To manage these complex networks effectively, gas utilities are increasingly relying on advanced technologies like GIS for leak detection, pressure monitoring, safety compliance tracking, and emergency response planning. Modern gas utility operations require highly accurate spatial intelligence to monitor network conditions, identify risk zones, and respond quickly to incidents. **GIS plays a central role in enabling precise asset mapping, infrastructure monitoring, and real-time decision-making, thereby improving both operational efficiency and public safety.** By providing actionable information, ArcGIS-powered systems are enabling large gas distribution companies like Mahanagar Gas Limited and Gujarat Gas Limited to provide a safe working environment, deliver reliable services, and maintain a focus on customer support.

By serving as a repository for consumer data, GIS enables the creation of thematic maps that aid in identifying future potential consumers. By studying demand-supply dynamics through surveys and mapping, CGD companies can formulate expansion strategies tailored to anticipated growth patterns, thereby ensuring scalability and sustainability.

GIS also enables gas utilities to achieve high levels of efficiency in asset management. Through precise tracking of pipeline assets like main and service lines, coupled with the calculation of relative distances, GIS empowers utilities to effectively monitor and manage their infrastructure. This capability not only enhances operational efficiency but also lays the groundwork for proactive maintenance strategies, mitigating the risks of leaks and accidents.

In the event of an incident, the swift response time facilitated by GIS is paramount. By providing real-time information to response teams, GIS ensures rapid and coordinated action, minimizing the potential impact on both public safety and the environment. By leveraging spatial data and advanced analytical techniques, GIS empowers operators to make informed decisions and take timely actions to address faults.

ArcGIS Enhances Efficiency of MGL's City Gas Distribution (CGD) Network

MGL's evolving business needs have been addressed by implementing a comprehensive GIS system that fosters collaboration and connectivity across different teams.

The new web application, powered by ArcGIS, is set to empower MGL's organization-wide GIS users by allowing them to access and visualize the MGL pipeline network and its assets from both office and field locations. This enhanced accessibility will equip users with valuable insights, enabling them to make informed decisions in the performance of their duties. Furthermore, MGL is actively engaged in the development of a Corrosion Protection (CP) module within ArcGIS. This module will serve as a valuable tool for recording TLP readings, conducting in-depth analyses based on these readings, and generating comprehensive reports within the software, thereby supporting the CP team's operational efficiency. Similarly, the valve chamber cleaning process flow is streamlined in order to manage the effectiveness of cleaning activities through intuitive mobile applications using Survey123 forms.

The integration of Survey123, ArcGIS JS API, and Dashboards creates a comprehensive GIS solution that caters to the diverse needs of departmental stakeholders, from field data collection to visualization and analysis. ArcGIS Dashboards provide a way to create data visualizations and present key indicators, charts and visual elements (attachments) captured from the field in a dashboard format. The GIS ecosystem also helps in reducing data silos and enabling different teams or departments to work with a unified dataset. This promotes collaboration and avoids duplication of efforts in maintaining separate datasets.

> *"The implementation of Esri's ArcGIS Enterprise solution at Mahanagar Gas Ltd. (MGL) marks a transformative milestone for the organization, bringing about a variety of benefits. Firstly, the new GIS system enhances overall performance, leveraging cloud implementation of the software for more efficient data processing, analysis, and visualization. This allows MGL to handle larger datasets and perform complex spatial analyses with greater ease. The advanced workflows and functionalities offered by Esri's GIS platforms, including ArcGIS Dashboards, provide a comprehensive view of assets under regional territories, empowering users to make informed decisions."*
> ***– Viraj Kulkarni, Ch. Manager - GIS, MGL***

Telecom

Telecommunication networks have become as critical to modern society as electricity infrastructure, serving as the digital nervous system that supports financial transactions, emergency services, remote healthcare, digital education, and industrial automation. India's telecom sector is experiencing unprecedented growth, driven by increasing mobile data consumption, nationwide 5G deployment, and the expansion of fiber optic connectivity into rural regions. Mobile data usage is growing by nearly 30% annually, while telecom tower density and digital infrastructure continue to expand significantly across the country.

Managing such vast and complex telecom infrastructure requires precise asset tracking, efficient fiber route management, accurate fault location systems, and continuous network optimization. **Technology-enabled telecom networks depend heavily on geospatial intelligence and GIS platforms to manage assets, monitor network performance, and ensure reliable service delivery.** As telecom infrastructure continues to scale rapidly, spatial technologies are becoming essential for planning, maintenance, outage management, and future network expansion.

At Esri India, we have witnessed the impact of GIS technology while working with the two major telecom service providers (TSPs) in India, Reliance Jio and Airtel. Jio has harnessed the various capabilities of ArcGIS during its 4G and 5G implementations, achieving

the most effective outcomes in network planning to management. ArcGIS has also enabled Airtel to map its network assets along with their coverage capacities. The technology allows the teams to collaborate, share, and perform a variety of spatial analyses such as identifying coverage blind spots, hotspot analysis, and network route planning.

Jio Achieves Excellence in AirFiber Deployment across India with ArcGIS

As India raced into the digital future, Jio introduced a groundbreaking service: Jio AirFiber. Designed to deliver gigabit-speed broadband over the air using 5G and unlicensed band radio (UBR) frequencies, AirFiber doesn't require traditional fiber lines to the home. Instead, it uses rooftop or in-building equipment to receive wireless signals directly from nearby towers. The result is an internet service that is fast to deploy, easier to install, and perfectly suited for dense urban areas or hard-to-reach regions where traditional fiber buildouts would be costly or slow. But deploying a service like this at a national scale—within months—demanded reimagining how telecom networks are planned, activated, and optimized. That's where GIS stepped in. Jio turned to geospatial technology to power every stage of its AirFiber deployment. At the heart of the effort was a national-scale 3D GIS system built on Esri's ArcGIS platform. From data preparation to planning, execution, and maintenance, GIS has been the connective foundation of Jio's AirFiber program. It has unified business units, enabled smarter decisions, and allowed one of the world's most ambitious telecom rollouts to happen on time and at an incredible scale.

Looking forward, as Jio continues to evolve its digital platform, GIS will remain at the heart of its strategy—connecting towers to homes, signals to services, and customers to what's important in their lives.

> *"We at Jio cannot envisage any other system than the one we built at the shortest possible time to support our AirFiber deployment. Super-fast planning and faster deployment helped us disrupt the broadband internet market by positioning AirFiber as a premium and affordable product with same-day installation time. Our continuous investment in GIS data, people, and Esri's technology along with AI and Cloud platforms helped us build these systems in-house at record speed."* ***- Dr. Biswaketan Kundu, VP and Head of GIS, Jio Platforms.***

As utility networks expand and become more complex, organizations require systems that can accurately manage infrastructure, monitor network behavior, and support faster decision-making. **This transformation depends on three critical pillars: data, connectivity, and visualization.**

The first pillar is **data**, which involves maintaining accurate and up-to-date asset information across the utility network. Utilities manage vast numbers of physical assets such as pipelines, transformers, substations, valves, meters, towers, and cables. Without reliable asset data, utilities struggle with maintenance planning, outage management, compliance reporting, and infrastructure expansion. GIS provides a centralized system for storing, managing, and updating this critical asset information.

The second pillar is **connectivity**, which focuses on understanding how utility networks function as interconnected systems. Utilities are not simply collections of individual assets; they are highly connected networks where one failure can impact thousands of customers. GIS enables utilities to model these network relationships, analyze connectivity, trace service paths, identify affected areas during outages, and understand how resources flow through the system. This network intelligence is essential for efficient operations and rapid incident response.

The third pillar is **visualization**, which allows utilities to see infrastructure relationships spatially and operationally. GIS transforms complex infrastructure data into intuitive maps and interactive visual systems that help operators, engineers, and decision-makers understand asset locations, network conditions, and operational risks in real time. Visualization improves planning, field coordination, situational awareness, and communication across departments.

Because GIS supports all three pillars, data management, network connectivity, and spatial visualization, it has become the operational foundation of modern utility systems. However, as utilities continue to evolve, traditional GIS approaches are no longer sufficient to handle the scale and complexity of modern infrastructure networks.

Today's utilities require advanced capabilities such as detailed network modeling, real-time system intelligence, enterprise-wide integration, and support for increasingly dynamic operations. They must manage rapidly expanding infrastructure, integrate data

from IoT sensors and smart devices, support predictive maintenance, and coordinate operations across multiple business systems. **This need has led to the emergence of modern GIS platforms designed specifically for advanced utility management.**

One of the most significant developments in this area is the **ArcGIS Utility Network**. ArcGIS Utility Network provides a next-generation framework for modeling, analyzing, and managing complex utility systems across electric, water, gas, telecom, and wastewater networks. ArcGIS Utility Network supports advanced network topology, real-time connectivity analysis, intelligent tracing, multi-user editing, and enterprise-scale integration. It enables utilities to create highly accurate digital representations of their infrastructure, often referred to as digital twins, which support better operational awareness and smarter decision-making. The platform also integrates seamlessly with enterprise systems such as SCADA, ERP, asset management, outage management, and field workforce applications, allowing utilities to move toward fully connected and intelligent operations.

As utilities worldwide adopt smart infrastructure strategies and digital transformation initiatives, ArcGIS Utility Network is becoming a critical technology platform that enables utilities to modernize operations, improve reliability, reduce operational costs, and build resilient infrastruwcture for the future.

Modern ArcGIS powered Network Information Management Systems offer improved data integrity and analysis capabilities. By understanding connectivity and device behavior, we can model subnetworks, improve data quality, and perform analysis to gain a better understanding of the system. Utility organizations can leverage these capabilities to meet their needs, most effectively.

GeoAI for Utilities

GeoAI, the convergence of Geospatial technology and Artificial Intelligence, is reshaping how utility organizations operate. By integrating AI with spatial data and geospatial technology, GeoAI empowers utilities to automate workflows, uncover patterns, and model future scenarios, enabling smarter, data-driven decision-making.

Demand Forecasting
Accurate demand predictions help optimize power generation, reduce energy wastage, prevent grid overloads, and support better infrastructure planning. This also assists in renewable energy management by forecasting fluctuations in energy consumption and production. As utility systems become increasingly complex due to rapid urbanization and climate change, advanced forecasting tools like Time-MoE within ArcGIS offer a scalable, data-driven, and intelligent approach for sustainable energy management and resilient utility planning.

Intelligent asset management & Failure Prevention
GeoAI can automate asset inspections using imagery, drone and sensor data, predict maintenance needs and infrastructure failures before they occur, manage vegetation-related risks through advanced image analysis, and improve data quality by identifying anomalies and inconsistencies.

Deep learning models within ArcGIS Pro can analyze asset conditions, environmental variables, and real-time sensor inputs to detect early warning signs of failure, enabling utilities to plan maintenance and inspections before issues escalate, reduce unplanned downtime, lower repair costs, and speed up field response. Similarly, by using imagery, LiDAR, and spatial analysis, utilities can **detect vegetation encroachment** risks near critical infrastructure, prioritize those risks by severity, and even predict future growth patterns, turning a perennial operational challenge into a manageable, proactive workflow.

Overall, by embedding GeoAI into their workflows, utilities can move **from reactive to proactive** operations, saving time, reducing costs, and improving service reliability, marking a fundamental strategic shift in how utility infrastructure and demand is monitored and managed.

Digital Twins and Utilities

For utilities, the value of a GIS-powered digital twin is wide-ranging and deeply practical. Investment planning becomes more informed as ArcGIS enables teams to visualize and analyze different system scenarios and model their potential impacts before committing resources.

Real-time data feeds from IoT devices are seamlessly integrated, formatted, and displayed in ways that generate actionable insights. Improved mapping and modeling bring greater clarity to the management of facilities and assets, while AI and machine learning capabilities support predictive maintenance and scenario simulation.

Digital twins break down departmental silos, enabling cross-functional collaboration and clearer communication with stakeholders, transforming utilities from reactive operators into proactive, data-driven organizations ready for the challenges ahead.

In Closing

As utilities navigate an increasingly complex digital landscape, the imperative to make data-driven decisions, contextualized to assets, consumers, and geographies has never been greater. Traditional technologies, constrained by their own boundaries, can no longer deliver the holistic visibility that modern utility management demands. **The future belongs to platforms and approaches that are self-learning, spatially aware, and capable of transforming vast volumes of operational data into actionable intelligence.** Utilities that remain ahead of the curve will be those that successfully connect assets, people, and processes into a unified, insight-driven ecosystem, one where consumer behavior, network performance, and business strategy are understood not in isolation, but in relationship with one another.

This is precisely where **GeoAI and Digital Twins are proving to be game changers.** GeoAI brings the power of machine learning and spatial intelligence together, enabling utilities to move from reactive operations to predictive, proactive decision-making, automating asset inspections, forecasting infrastructure failures, and optimizing field workflows with unprecedented accuracy. Digital Twins complement this by creating living, dynamic models of utility networks that simulate real-world scenarios, support investment planning, and foster cross-functional collaboration in ways that were previously unimaginable. Together, they represent the convergence of intelligence and geography that utilities need to thrive.

With more than 90% of utility enterprise data carrying a location context, geography remains the most powerful and underutilized binding factor across the supply-demand and source-consumer continuum. **GIS-driven utility management, augmented by GeoAI and Digital Twin capabilities, is no longer simply a technological upgrade, it is a national development imperative, one that must be embraced at full scale, and with urgency, to build a resilient, sustainable, and consumer-centric digital future.**