GSMA

IoT and Essential Utility Services:
Opportunities in low- and middle-income countries

GSMA

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GSMA Digital Utilities

Utility services such as energy, water, sanitation, waste management and transport are essential to life. The Digital Utilities programme enables access to affordable, reliable, safe and sustainable urban utility services for low-income populations through digital solutions and innovative partnerships. In doing so, we also seek to support cities in low- and middle-income countries in their transition to a low carbon, climate-resilient future.

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Abbreviations

3GPP	3rd Generation Partnership Project
AI	Artificial intelligence
AMI	Advanced metering infrastructure
GSM	Global System for Mobile Communication
ICT	Information and communications technology
IoT	Internet of things
ITU	International Telecommunication Union
LAN	Local area network
LEO	Low Earth orbit
LMIC	Low- and middle-income country
LPG	Liquefied petroleum gas
LoRaWAN	Long-range wide area network
LPWAN	Low-power wide area network
LTE	Long-term evolution
LTE-M	Long-term evolution for machines Type Communications Category M1
M2M	Machine-to-machine
MNO	Mobile network operator
MVNO	Mobile virtual network operator
NB-IoT	Narrowband IoT
NRW	Non-revenue water
PAYG	Pay-as-you-go
SHS	Solar home system
WAN	Wide area network
WBE	Wastewater-based epidemiology

Glossary of key terms

IoT

Describes the coordination of multiple machines, devices and appliances connected to the internet through multiple networks.

Latency

Latency refers to the time taken for a packet of data to travel between two points, typically measured in milliseconds.

Licensed LPWA

The mobile industry has focused on developing two complementary LPWA technologies: LTE-M and NB-IoT. Both use licensed spectrum. LTE-M is better suited to devices that require voice support and mobility, while NB-IoT is more appropriate for stationary objects such as smart meters

LoRaWAN

An LPWA technology designed to wirelessly connect devices to the internet using unlicensed spectrum. Semiconductor company Semtech holds the intellectual property (IP) for LoRaWAN-supporting chipsets and earns a royalty on each device sale. However, the development and promotion of LoRaWAN technology and its ecosystem is led by the LoRa Alliance, which includes more than 500 member companies.

LPWA

LPWA technologies have been optimised to serve the IoT market, specifically applications requiring low data rates and infrequent transmissions. Examples of LPWA networks include LoRaWAN, LTE-M, NB-IoT and Sigfox.

M2M

Communication between two or more entities that do not necessarily need any direct human intervention. M2M services intend to automate decision and communication processes.

Mobile virtual network operators (MVNOs)

Connectivity service providers that do not own the network infrastructure on which they provide their services, rather, they lease it from mobile network operators (MNOs).

Peak data rates

Maximum achievable data rate per user measured in bits per second.

Reference architecture

The reference architecture model provides, at a high level, the technology components of a solution. It also provides a common vocabulary with which to discuss implementations.

Sigfox

The most extreme of the LPWA technologies in that it supports very low data transmissions and messaging capabilities to push battery life to its limits. Sigfox uses unlicensed spectrum. Sigfox technology is owned by UnaBiz and licensed to Sigfox Network Operators in individual countries.

Foreword

The GSMA projects that IoT connections across Sub-Saharan Africa, South and South East Asia are set to double by 2030 to 156 million devices. According to McKinsey & Company, in 2020 IoT generated $1.3 trillion in economic value, with 16% of this coming from emerging markets. According to their projections, IoT could generate $5.5 trillion to $12.6 trillion in economic value globally by 2030. In the Kenyan market, the adoption of IoT is set to grow as companies are looking at IoT solution to improve customer service, enable process automation, and support better decision making, amongst others.

Key to adoption in low- and middle-income countries (LMICs) is the availability of GSM networks. In Kenya 2G population coverage is at 96%, 3G at 99%, 4G at 98%, and 5G at 2% and growing. This high coverage has enabled the deployment of IoT devices and the emergence of use cases across the country. There is also a growth of Low Power Wide Area Networks (LPWA), which enable battery powered IoT devices that have a longer life cycles. Advancements across technology groups are also driving adoption: sensors increasingly cover the full spectrum from visual to acoustic; computing speeds are meeting requirements; storage options are growing; improved battery technology is extending possibilities; and artificial intelligence and machine learning are driving advanced data analytics.

As adoption of IoT steadily grows in LMICs, concerted efforts by various stakeholders such as private sector innovators and suppliers, customers, regulators, policymakers, funders are needed to deal with the challenges limiting adoption. In particular , these include issues around interoperability and cybersecurity. There is also the need for capacity building across the ecosystem. As IoT is nascent in many LMICs, there is need for training on what it is, how to adopt it, and the risks that come with different use cases. Deployments must also be accompanied with change management processes. IoT projects are currently perceived by many businesses as IT projects, but they are truly business transformation projects. Businesses and organizations must align and make the required procedural, organisational and cultural changes to really reap the benefits associated with IoT. A supportive policy environment for the adoption of IoT is equally critical. Governments and regulators can also drive adoption by incentivizing and supporting utilities to deploy smart meters to improve their commercial sustainability.

Safaricom PLC is at the forefront of developing IoT solutions across a range of sectors and use cases. Our IoT strategy has four key pillars: strong vertical focus - we are building and deploying solutions that solve the different challenges within specific verticals; strong technical expertise - we are building expertise in these verticals and technologies to augment our telecommunication expertise; building relevant partnerships - we are collaborating with different players such as IoT innovators, development partners, policy makers to offer relevant solutions; and lastly, leveraging on our network coverage to connect IoT devices securely across the country.

As the report highlights, the utility sectors will be at the forefront in driving IoT growth not only in Kenya but also in other LMICs. Smart utility management is one of our key areas of focus, and we are working to deliver smart utility solutions in both the public and private sectors. One of the areas that presents great opportunity is the water sector. In Kenya, the sector loses approximately KSH 11 billion annually, and non-revenue water averages over 40%. We are supporting water service providers to address this challenge. For example, Eldoret Water and Sanitation have deployed smart meters and seen a decline on non-revenue water by 5%, with the project ongoing. In addition to smart utilities solutions, we have also built solutions for transport and cold chain, and are exploring opportunities in manufacturing, health, and education.

The future of IoT in the LMICs is bright. Businesses and organizations are realizing IoT will drive business transformation and sustainability. This report provides valuable insights on how IoT is impacting the utility sector, and is a must read for companies working on delivering IoT solutions, as well as policy makers and other partners working to create the enabling environment for adoption.

Jerry Teka,
Lead – IoT Business,
Safaricom PLC

Executive summary

IoT connections across sub-Saharan Africa, South and Southeast Asia are set to double by 2030. Cellular IoT connections across these three regions will reach 156 million by this date. This expansion is thanks to an increasingly rich array of connectivity technologies becoming available across markets, the high coverage of cellular (2G, 3G, 4G) networks, and a vibrant and growing ecosystem supporting deployments.

A major trend defining the next decade is that enterprise IoT will overtake consumer IoT in terms of number of connections. The utilities sectors will account for a major proportion of this growth. For example, in Sub-Saharan Africa smart utility IoT connections will increase almost six-fold between 2021 and 2030. With total IoT connections in the utilities sectors (cellular and non-cellular) reaching 152 million. By 2030, utility solutions will account for nearly 30% of IoT connections in the region. Similar trends can also be seen in LMICs in South and Southeast Asia.

The strong growth forecast in the utilities sectors reflects the scale of the opportunities IoT holds for improving services. IoT is pivotal to digital solutions that tackle water shortages, lack of sanitation, unreliable power, and insufficient waste management, often working in tandem with digital payments, big data analytics and AI.

This report reviews the extend to which 17 key utilities-focused use cases have been deployed across five markets. Through interviews across the ecosystem, it assesses the state and maturity of deployments in Indonesia, India, Kenya, Nepal, and Nigeria. By drawing together the findings across these market cases studies, it also identifies trends that are relevant across LMIC market contexts.

This report is a companion to the recently published GSMA report, *IoT for Development: Use Cases Delivering Impact*. That report provides a more detailed discussion of the solution architecture for IoT, provides data on the connectivity options in 62 markets in Sub-Saharan Africa and South and Southeast Asia and discusses a broader range of use cases across the climate, health, agriculture and humanitarian sectors.

Key trends in utility sector IoT deployments

Energy was the most advanced sector in terms of deployments across markets. With tens of millions of smart meters already deployed, and ambitious national plans across markets to deploy hundreds of millions more over the coming decades. In many cases large national procurements are spurring growth in the ecosystem, with governments specifying requirements surrounding local manufacturing. The rapidly growing off-grid energy sector, exemplified by IoT-enabled micro-grids and pay-as-you-go services, is approaching maturity in some markets. This is central to meeting SDG 7 targets, as off-grid energy has been identified as the least-cost electrification option for 41% of those without power.

In water, smart metering was also identified as the most prevalent use case, though with fewer large-scale deployments than in energy. This reflects some of the market conditions in the water sector, but also highlights that devices require an independent power supply, raising unit costs. An encouraging new trend is the growing number of solutions in the market for monitoring water systems and resources, and tracking disease outbreaks. A quarter of the world's population live in countries already facing "extremely high" water stress, and business leaders consistently rank water crises in the top five global risks by impact. The climate crisis is a water crisis, and cities' and society's prosperity rests of a reliable water supply. The IoT solutions identified give states, utilities, and individuals new capacities to meet the coming challenges.

The sanitation and waste management sectors share very similar characteristics. Both value chains are often highly fragmented with many collectors aggregating waste from households that is later centralised for recycling or safe disposal. In these contexts, IoT, combined with digital solutions such as platforms and blockchain, enables traceability across the value chain. Despite the opportunity both sectors are at a nascent stage across markets. However, some mobile operators, and many companies in the ecosystem, are beginning to market tailored solutions. Both sectors are particularly well placed to benefit from the expansion of IoT-enabled logistics solutions such as asset tracking and fleet management, which have the potential to improve coordination and multi-stakeholder collaboration across urban service delivery value-chains.

Asset tracking is among the most mature transport IoT use cases in all the case study markets. The hardware is widely available due global market maturity, is also relatively easy to install, and most solutions can make use of the high 2G and 3G coverage. There is also an exciting pipeline of electric vehicle solutions, and while deployments are at an early stage there is an enabling policy environment in many countries, and a strong investment pipeline. For example, in Africa transport and logistics is the third largest sector in terms of deal value for tech-focused investment on the continent, attracting $1.4 billion in investment in the past four years.

Accelerating adoption

To maximise the potential of IoT opportunities in the utility sectors, the following actions are likely to support adoption across markets. These recommendations work in concert with those published in the companion *IoT for Development* report.

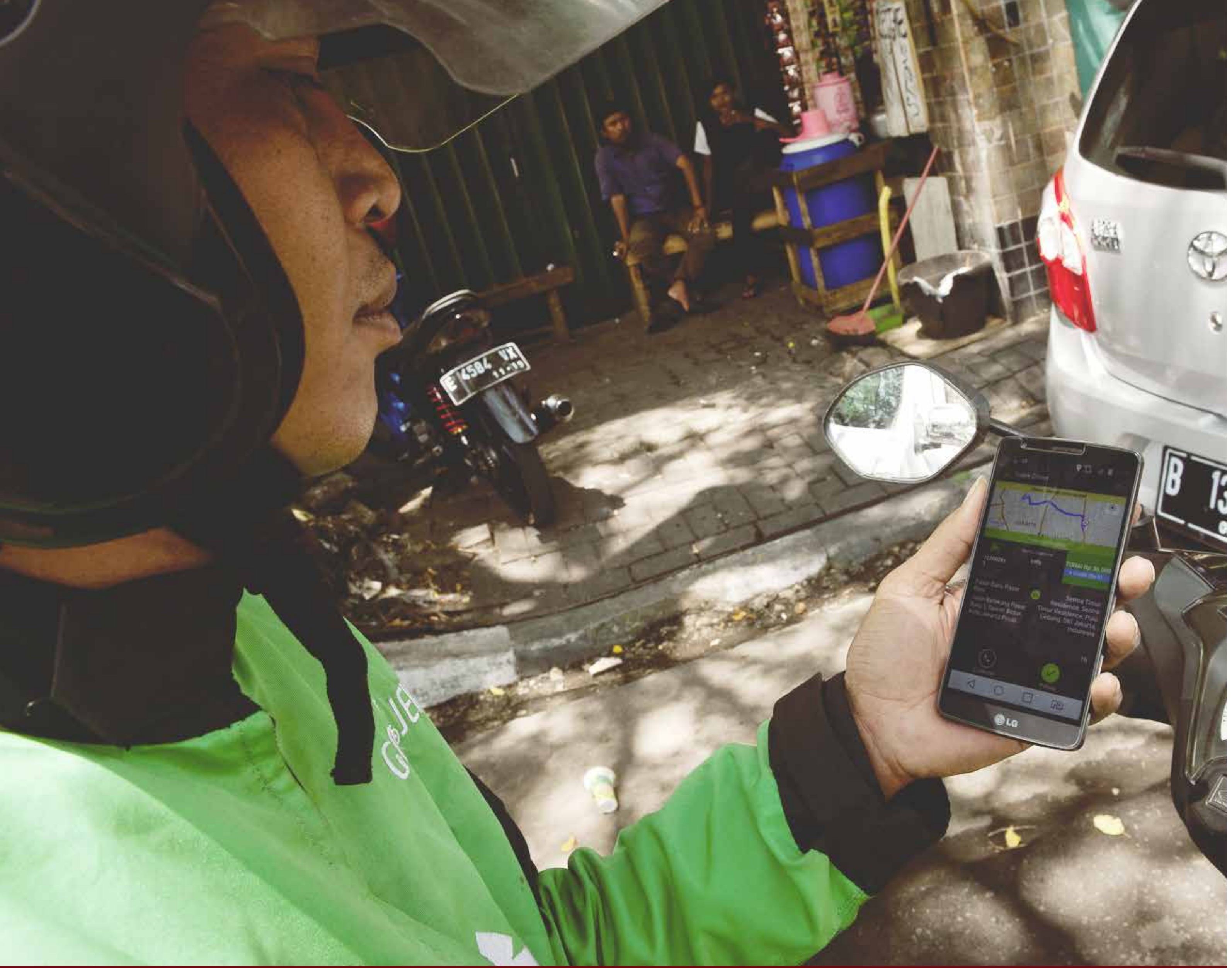
As such a high-growth vertical, mobile operators require a clear strategy to remain competitive. Beyond price, many are developing sector-specific services and applications. The utilities sectors also offer co-benefit, particularly in energy where customer access to electricity boost digital engagement and mobile money usage, and the opportunities for cell tower sites to draw on decentralised energy.

Utility service providers can benefit from developing their IoT capabilities. Where these are nascent pilots and partnerships are essential for appraising options ahead of large-scale deployments. Procurement processes, and cost, were often cited by utilities as the greatest challenge. Enabling policy that encourages utilities to test digital innovations and partner with private sector innovators and startups can begin to overcome some of these challenges. However, in the case of critical infrastructure, there is also the need to look beyond narrow cost-benefit analysis to consider the social, economic, and environmental consequences of services failing.

Innovators and solution providers can benefit from developing clear value propositions. In many cases there is a strategic decision to be made on the focus of core competencies (esp. hardware vs software). Once a focus is fixed, identifying suitable partnerships, with mobile operators and across the ecosystem, to complement and augment capacity and service offerings is central to scale and impact.

Our research for this paper has clearly highlighted the central role policymakers play in shaping deployments. Large-scale deployment, particularly in energy, with requirements for onshoring manufacturing have spurred the development of the ecosystem. The wider enabling environment for deployments includes regulator certainty around spectrum, security requirements, and data management. Policymakers can also take a lead on skills and training, supporting the emergence of the talent needed for the digital economy.

The research that has informed both this report and the GSMA IoT for Development paper has clearly highlighted the opportunities coming in the next decade. While IoT connections in the focus regions are set to double to 2030, there is still significant room for growth beyond that point. Relative to population, the regions covered by this study will account for a small proportion of global IoT connections. Growth in other regions are likely to support deployments globally, but harnessing the opportunity within specific markets requires focused partnerships and investments in developing the ecosystem from governments, enabling organisations, and financing partners. Given that many ecosystems and use cases across LMICs are still at a nascent or emerging stage, such engagement is particularly vital now to ensure that IoT use cases and deployments maximise developmental impact and help address pressing societal challenges.



1 Introduction

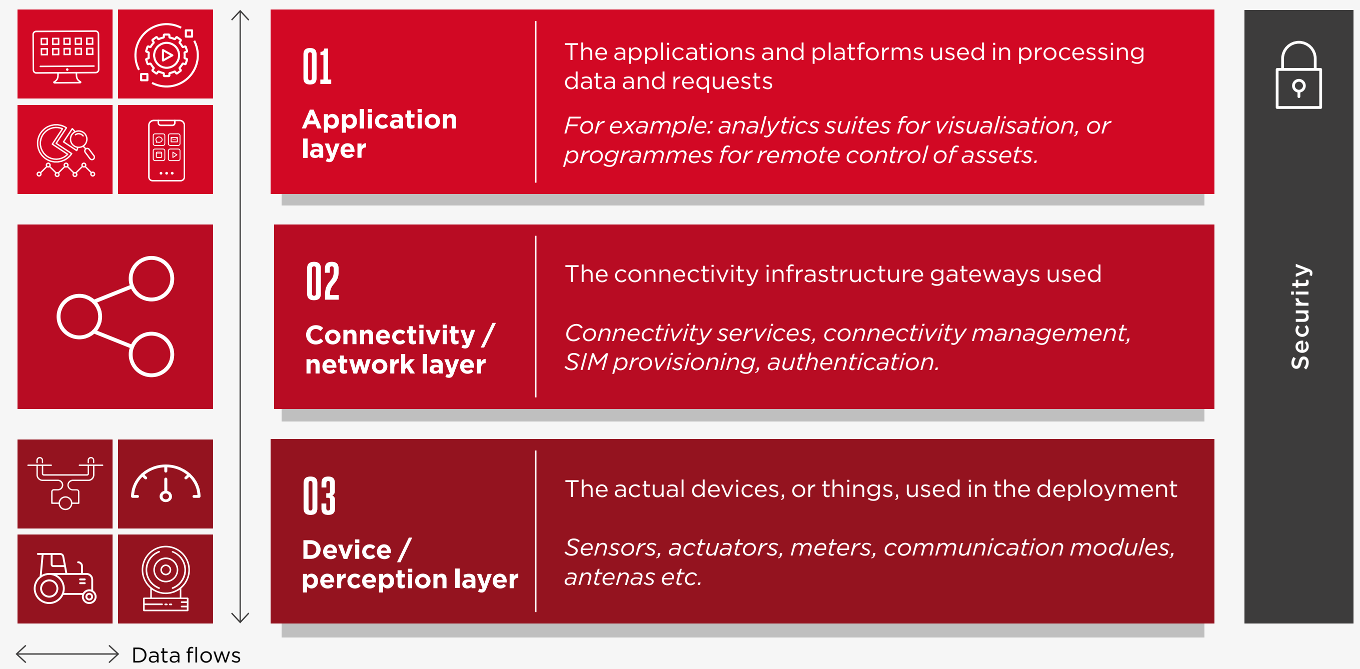
GSMA Intelligence forecasts that smart utilities Internet of Things (IoT) connections will total 3.5 billion globally by 2030, up from 1.7 billion in 2021. Growth will be particularly strong in low- and middle-income countries (LMICs), where many companies are still in the early stages of their IoT journeys. In Sub-Saharan Africa, for example, smart utilities connections will increase almost six-fold between 2021 and 2030, reaching 152 million. By 2030, utility solutions will account for nearly 30% of IoT connections in the regions. Similar trends can also be seen in LMICs in South and Southeast Asia.

Mobile-enabled digital solutions are uniquely placed to address the challenges facing utility sectors, including water shortages, lack of sanitation, unreliable power and insufficient waste management. IoT is pivotal to many digital solutions, often working in tandem with other mobile technologies. For example, mobile money services and IoT-enabled solar home systems (SHS) have made energy more accessible and affordable for millions, while the combination of IoT sensors, big data analytics and artificial intelligence (AI) can rapidly improve planning and resource management in areas such as water and sanitation.

This report analyses the main IoT use cases in the energy, water, sanitation, waste management and transport sectors through detailed market case studies in India, Indonesia, Kenya, Nepal and Nigeria. These countries were selected to provide examples from a range of regions and market contexts. Our findings draw on two main sources: i) key informant interviews with companies working across the IoT ecosystem, and ii) desk-based research on IoT developments in the utility sectors. The five market case studies are summarised in this report, featuring lessons from different use cases and contexts. To read more about a specific market, longer case studies of each market are available on the GSMA Digital Utilities website.

Figure 1

IoT solution reference architecture



Note: This depiction of the IoT reference architecture is an adaptation of the original IoT reference architecture as published by the ITU and represents a simplified view of an IoT solution. In reality, IoT solutions are comprised of many devices, sensors, actuators and other connectivity-enabled 'things' that may receive one or more types of communication service.

This report is a companion to the recently published GSMA report, 'IoT for Development: Use Cases Delivering Impact'. It provides a more detailed discussion of the solution architecture for IoT, provides data on the connectivity options in 62 LMIC markets in Sub-Saharan Africa and South and Southeast Asia and discusses use cases across the climate, health, agriculture and humanitarian sectors.

Core IoT concepts

Not a technology itself, IoT instead integrates various technologies related to sensing, automation, software and cloud computing. Described as end-to-end, an IoT solution will always consist of three distinct layers: a sensing device that receives a connectivity service and an application that performs the task. It is important that all layers have a security component as security functions are necessary for each one. Figure 1 illustrates the simplified reference architecture for IoT deployments.

An increasingly rich array of connectivity technologies are being used to support the demands of IoT applications. The first major distinction is between short-range and wide-area connectivity. Short-range technologies account for most connections and are common for consumer IoT in the home, as well as enterprise solutions operating in a fixed and relatively defined geographical area. In this report, we focus on wide area networks (WANs), which are widely used for use cases across utility solutions.

Different networks have their own benefits and drawbacks, and the most appropriate network will almost always be solution-specific. However, there are some general attributes that should be considered when determining the most appropriate network for utility IoT deployments. Range, maximum data rates, latency and battery requirements for devices are often the key determinants. Figure 2 highlights the main connectivity technologies, and their key advantages and disadvantages.

While cellular M2M networks currently account for most IoT connections in LMICs, LPWA technologies are expected to experience much stronger growth in the next decade. LPWA technologies differ in that they have been optimised to serve segments of the IoT market, specifically applications requiring low data rates and infrequent transmissions, such as smart metering and asset monitoring. The low power aspect of LPWA technologies means they can provide battery life of up to 10 years for connected devices. The IoT for Development report has further details of the trends underpinning IoT deployments, country-level data on network deployments and coverage, and a more extensive discussion on network technologies.

Figure 2

Main connectivity groups

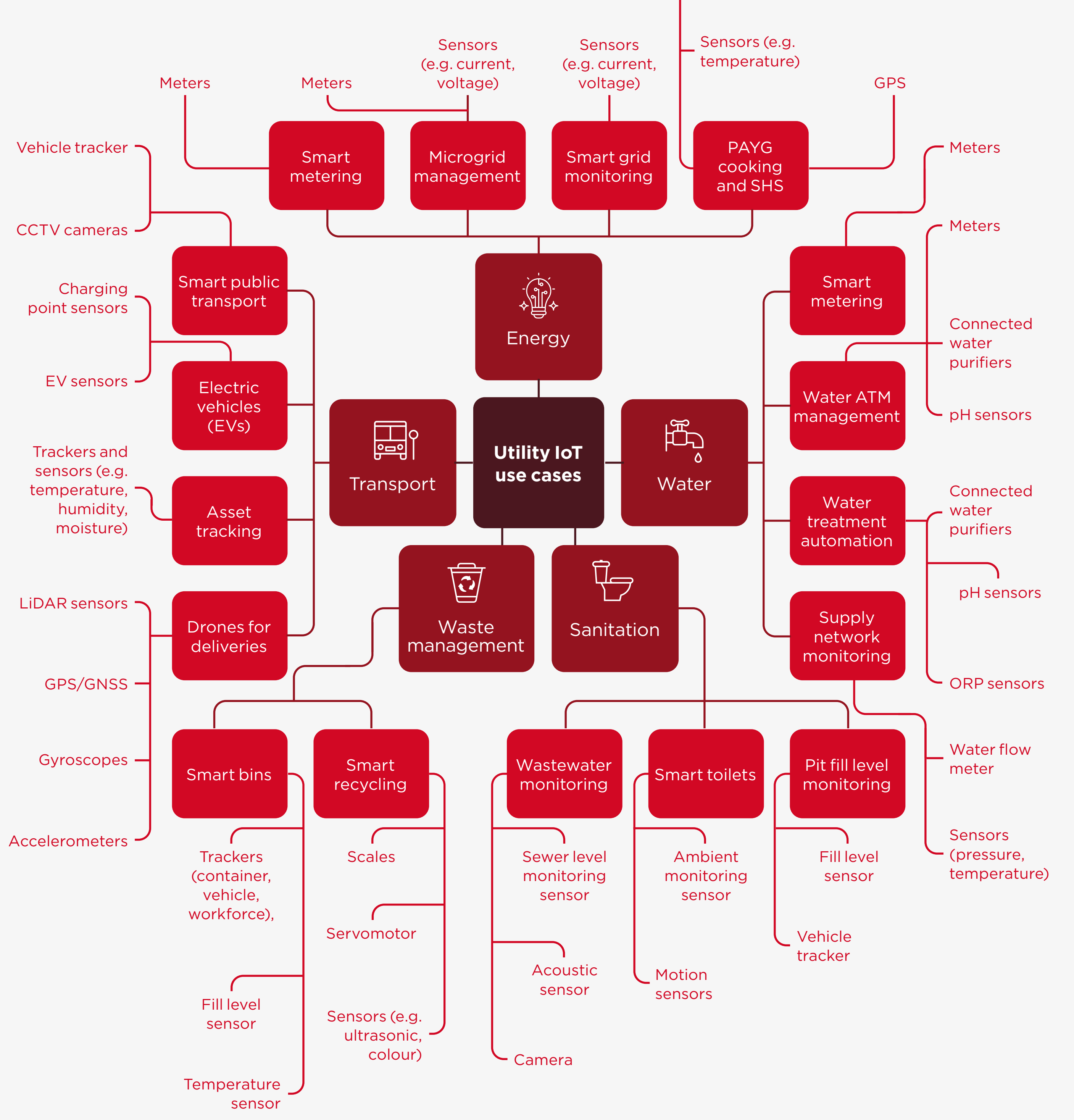
Group		Description	Main advantages	Main disadvantages
Short-range technologies		This group of technologies provide in-building connectivity. Applications that require high bandwidth normally use Wi-Fi, while low bandwidth applications rely on Bluetooth.[8] These technologies are not within the scope of this research.	• Supported by wide array of devices (e.g., mobile phones) • Low-cost connectivity hardware	• Limited area coverage • Limited mobility
Cellular M2M		This consists of 2G, 3G, 4G and 5G networks, which are examples of wide-area connectivity technologies designed to support a broad range of services.	• Good coverage • High data rates • Established vendor ecosystem • Established international roaming agreements	• High power consumption limits battery life • Higher device unit cost
LPWA	Licensed	LPWA technologies have been optimised to support machine-type communications. The mobile industry has focused on two complementary licensed technologies: LTE-M and NB-IoT	• Low power consumption (longer battery life) • Low-cost connectivity hardware	• Not yet globally deployed • Low data rates • More nascent vendor ecosystem
	Unlicensed	This class of LPWA technologies uses unlicensed spectrum. It includes LoRaWAN and Sigfox, and many other smaller companies (e.g., Kerlink and Microchip)		
Satellite		Satellite is a niche solution, mostly used to connect IoT devices in remote places.	• Coverage in very remote areas • Suitable for tracking across large distances	• Lower data rates (for most satellite deployments) • Higher latency

2 IoT in essential utility services

In this report, we examine 17 common utility IoT use cases. This is in no way an exhaustive list, but were considered the most likely to be implemented in the markets we studied and have significant benefits for utility providers and customers. Figure 3 highlights these use cases by sector and some of the most-used devices. Annex 1 provides additional details on the use cases and key benefits that can be expected from IoT deployments. For each of the market case studies, the sectors were reviewed to identify where, and to what extent, these use cases had deployments. Throughout this report, we draw attention to the innovators and companies leading IoT deployments.

Figure 3

Key utility IoT use cases



2.1 IoT solutions by sector

Energy

Over the past decade, a greater share of the global population gained access to electricity than ever before, but the absolute number of people without electricity in regions such as Sub-Saharan Africa increased. As of 2020, more than 730 million people globally were still living without any access to energy.[1] However, access is a poor measure of quality, and many urban residents face challenges with affordability and intermittent supply. IoT deployments are central to both on-grid and off-grid energy systems and have an important role in bringing the two together.

Smart energy meters are a key use case and account for a large proportion of deployments in all sectors. IoT is central to monitoring energy usage and linking it to payments, which is essential for PAYG solar and microgrids. As renewable generation capacity accelerates, national grids are adapting to accommodate a wider range of sources and many smaller producers. Smart grid solutions depend on accurate real-time data, and IoT is a core component of the grids that will support our energy transition.

Water

Rising water demand combined with limited, and often vulnerable, freshwater resources is exacerbating the challenge of delivering affordable, safe and clean water in urban areas. This highlights the need for city authorities, water utilities and their partners to employ new water management solutions. Compared to energy, IoT adoption in the water sector has been slower. In part, this is due to different market conditions. Water is relatively cheap for utilities to "produce", and fixing leaky infrastructure is expensive as much of it is underground and can be hard to locate. Although better data and information may not be sufficient motivation for utilities to deploy IoT at scale, effective metering and revenue collection are central to a healthy, functioning utility and many struggle to collect their tariff revenues.[2] Smart metering clearly has a role to play in breaking the vicious cycle of low revenue collection and poor service.

Beyond the economic argument, ensuring public health and environmental standards are also strong drivers for IoT adoption in the water sector. As we will discuss in this report, IoT has a key role in monitoring harmful discharges from industry and households into water bodies. We are increasingly seeing legislation that is turning to IoT and other digital solutions to enforce this.

Waste management

Rapid urbanisation is creating a looming waste crisis. With more people living in cities, it is becoming more common to see waste filling up streets and blocking drainage and sewerage systems, contributing to ecological degradation and pollution of water reserves. With IoT and cloud-based intelligence, waste containers can be tracked, fleets can be managed and innovative new devices can be developed to improve the recycling process. Waste management value chains are often highly fragmented with many, often informal, waste collectors aggregating waste from many households, that is later centralised for recycling or safe disposal. In these contexts, IoT, combined with digital solutions such as platforms and blockchain, enables traceability across the value chain. This is increasingly important as many governments pursue extended producer responsibility (EPR) policies to stem the flow of plastics into the environment.

Sanitation

Lack of access to sanitation services causes a range of negative impacts, from water contamination and environmental degradation to poor school attendance and endemic disease. As with waste management, many sanitation value chains are fragmented, with waste collected from households and then centralised for safe treatment and disposal. Here, IoT has a role when combined with platform models for coordinating and tracking safe disposal. As with other use cases, the benefits of preventing harmful discharges of waste extend beyond the balance sheet of a single organisation,

1. World Bank. (2022). *Off-Grid Solar Market Trends Report 2022 : State of the Sector*.
2. Authors' analysis of IBNET data. See: https://www.ib-net.org/. Accessed September 2021.

and there is a string of public health reasons to financially support deployments. The COVID-19 pandemic spurred attention to wastewater-based epidemiology,[3] an emerging field in which sewage is tested to monitor and model disease outbreaks. IoT devices is a powerful tool for scaling these efforts and lowering monitoring costs. Increasingly, specialised firms are developing the devices needed to deploy at scale.

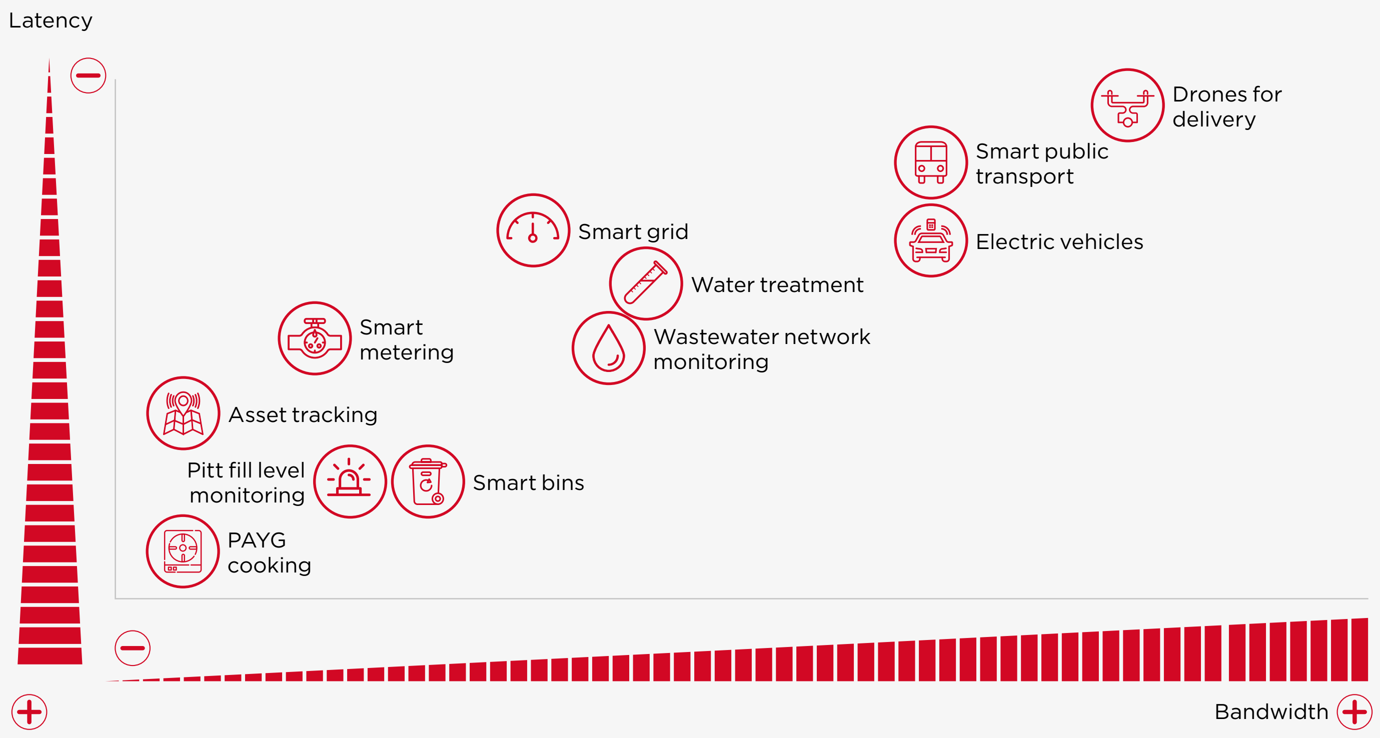
Transport

In many cities, rapid urbanisation is putting pressure on existing mobility infrastructure, causing congestion and stretching the capacity of public transportation networks. The result is higher levels of pollution, limited mobility options for the urban poor and reduced productivity in cities. These challenges provide an opportunity to improve the efficiency of transport systems by harnessing IoT solutions for safety, managing city infrastructure efficiently and offering innovative financing models for electric vehicles (EVs). Beyond passenger travel, IoT is becoming more pervasive in logistics and delivery, with important implications for trade and growth. Historically, many markets have struggled with logistics, and large quantities of agricultural produce are lost due to lack of access to markets. Asset tracking, as well as more niche use cases like temperature and humidity monitoring in transit, are becoming more prominent. These developments are important as they provide a foundation for economic growth and support the emergence of e-commerce in many markets.

3. Adhikari, S. and Halden, R.U. (May 2022). "Opportunities and limits of waste-water-based epidemiology for tracking global health and attainment of UN sustainable development goals". *Environment International*, Volume 163.
4. Bandwidth refers to the maximum amount of data that can be transmitted in a given amount of time, while latency refers to the time it takes for a packet of data to travel between two points, typically measured in milliseconds.

Figure 4

Bandwidth and latency requirements of IoT use cases[4]



2.2 Requirements for IoT use cases

Key to understanding IoT deployments is understanding what is required for various use cases. Different deployments require different hardware, but what is not often discussed is the solution-network fit and how connectivity technologies influence the practicality and commercial viability of deployments. In this section, we highlight some of the key attributes of the use cases discussed throughout the report.

The selected use cases have a range of network requirements. For example, some drone use cases will require 5G networks to deliver the necessary speeds and latencies. Meanwhile, EVs and smart public transport applications (e.g. CCTV on buses) may require upgraded networks to cope with higher data transfer volumes. Use cases with stricter network requirements have more challenges reaching scale because the quality of connectivity needed is less likely to be readily available, particularly in lower income markets. This is in contrast to monitoring use cases, which can perform at low speeds. LPWA technologies are particularly suitable for use cases that send infrequent, small messages and where low latency is not a critical requirement. Examples include smart metering, asset tracking and infrastructure monitoring (e.g. water supply network monitoring and pit fill level monitoring). Figure 4 outlines general differences in the speed and latency requirements of the use cases.

Connectivity requirements can be further analysed by looking at static and mobile assets. Static assets can be supported by various technologies. For example, smart meters may use a fixed line connection or a cellular connection. The lack of fixed infrastructure in LMICs means that cellular is often used to connect static devices, especially when they are geographically dispersed (e.g. microgrids). Static assets can be connected directly to the network, or they may use a local area network (LAN) to connect to a gateway that then connects to the macro network. Figure 5 highlights the differences in these requirements.

There are also differences in how IoT use cases integrate with other parts of the digital ecosystem, such as financial services. The widespread adoption of digital payments (in particular, mobile money services) can support IoT growth in areas such as smart metering, SHS and PAYG cooking devices. These use cases leverage PAYG business models which, in turn, improve access to services such as water and energy because they give people the ability to pay for what they use as they need it.

A wide range of sensing and actuating devices, gateways and cameras are employed across the use cases. These devices have a range of requirements. Battery life is a common priority for use cases such as pit fill level monitoring or wastewater monitoring, where devices are deployed in hard-to-reach areas and it is expensive to replace hardware. These and other use cases (e.g. smart bins) also often require durable devices due to the conditions in which they operate. This often means additional costs, such as placing protective casings around devices to guard against the corrosive environment and ensure the device is waterproof. Size is also an important consideration for sensors that are attached to other objects, such as asset trackers and fill level monitors. Likewise, drones deployed for deliveries must meet certain size and weight requirements.

Figure 5

Assessment of IoT use cases by different parameters

Sector	Use case	Mobile vs static devices	LPWA suitability	Mobile money integration
Energy and water	Smart metering	Static	High	Yes
Energy	Smart grid	Static	Good	No
	PAYG cooking and SHS	Static	Good	Yes
	Microgrids	Static	High	Yes
Water	Water ATMs	Static	High	Yes
	Water treatment	Static	Good	No
	Supply network monitoring	Static	High	No
	Wastewater monitoring	Static	Good	No
Sanitation	Smart toilets	Static	Good	Yes
	Pit fill level monitoring	Static	High	No
Waste management	Smart bins	Both	High	No
	Smart recycling	Static	Good	Yes
Transport	Smart public transport	Mobile	Some	Yes
	EVs	Mobile	Some	No
	Drones for deliveries	Mobile	Some	No
	Asset tracking	Mobile	High	No

3 Market reviews

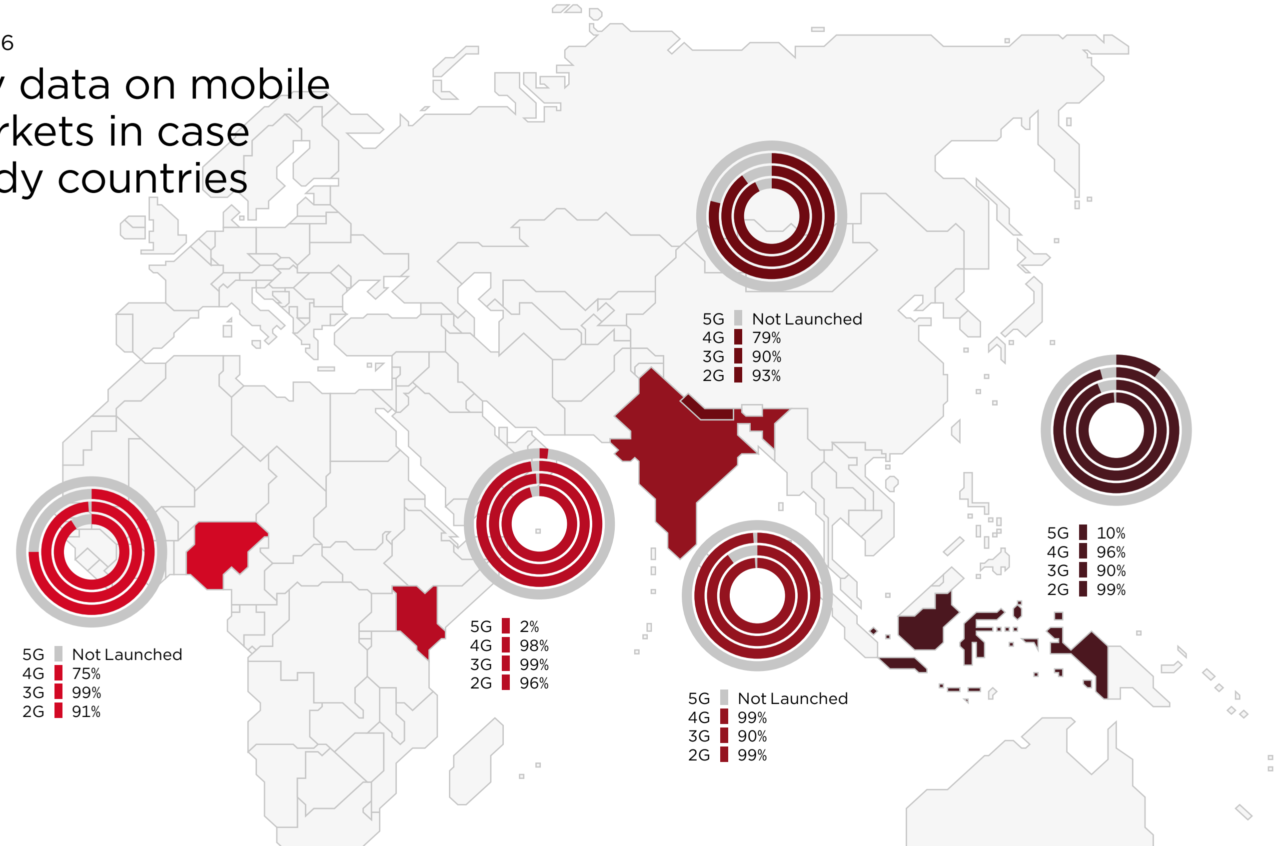
This section examines the state of IoT deployments in the energy, water, sanitation, waste management and transport sectors. The five countries featured in this report were selected from a range of regions and development levels to ensure the findings were applicable across many LMICs. The five countries also have different-sized economies and mobile markets with different characteristics in terms of mobile penetration, smartphone adoption and available LPWA technologies. These differences allow us to examine the importance of various enablers for IoT deployments within the utility sectors.

This report includes a two-page summary for each country. The full market case studies are published separately:

- Read the full **India** case study here
- Read the full **Indonesia** case study here
- Read the full **Kenya** case study here
- Read the full **Nepal** case study here
- Read the full **Nigeria** case study here

Figure 6

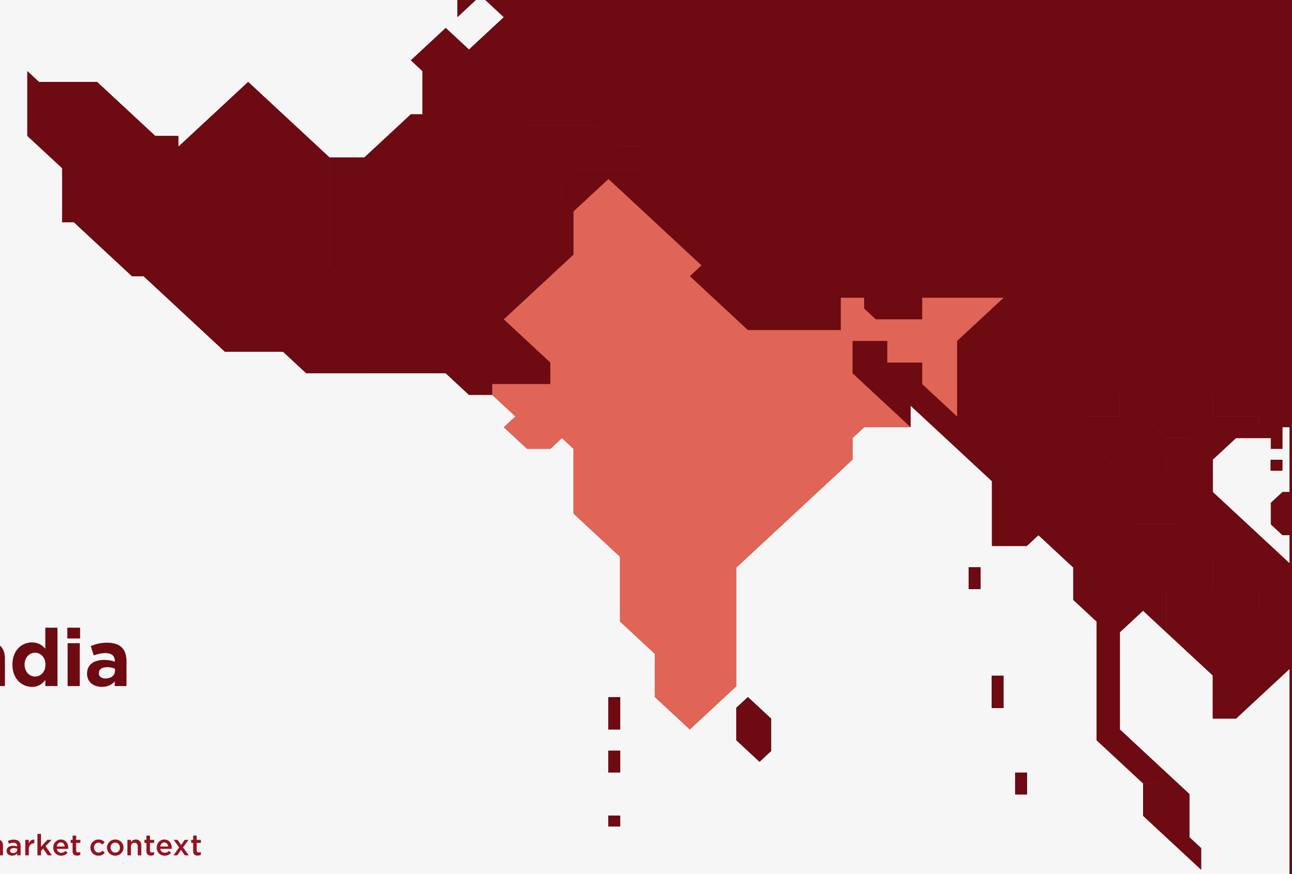
Key data on mobile markets in case study countries



	Nigeria	Kenya	India	Nepal	Indonesia
Mobile penetration[a]	47%	55%	63%	68%	55%
Mobile internet penetration[b]	27%	32%	48%	44%	46%
Smartphone adoption[c]	50%	49%	76%	57%	82%
Made or received a digital payment	34%	69%	35%	29%	37%
GSMA Mobile Connectivity Index (MCI) score (out of 100)[d]	54	53	61	50	69
LPWANs:	NB-IoT, Sigfox, LoRaWAN	NB-IoT, Sigfox, LoRaWAN (open community network only)	NB-IoT, Sigfox, LoRaWAN	None launched	NB-IoT, Sigfox, LoRaWAN

Notes on indicators: a) defined as unique mobile subscribers as a percentage of the population, b) defined as unique mobile internet subscribers as a percentage of the population, c) percentage of connections, d) the GSMA Mobile Connectivity Index measures the performance of 170 countries – representing 99% of the global population – against key enablers of mobile internet adoption: infrastructure, affordability, consumer readiness and content and services. More details can be found at: mobileconnectivityindex.com.

Source: GSMA Intelligence for all indicators except "made or received digital payment", which is from the World Bank's Findex Database 2021. Data accurate as of December 2022.



3.1 India

Policy and market context

In 2015, the Indian government introduced the Digital India programme, which aims to transform the country into a digital society and economy. As part of Digital India, the Centre of Excellence for IoT (CoE-IoT) was created in Bangalore to kick-start India's IoT ecosystem. The centre includes a co-working space and an innovation lab to support hardware manufacturers. Digital India also supports IoT manufacturers through the Production Linked Incentive Scheme, which has recently been extended to include smart meters.[5] Beyond Digital India, the Indian government has allocated Rs 1 lakh crore (around $12 billion)[6] to the Smart Cities Mission to drive additional IoT deployments.

India's IoT ecosystem benefits from a rapidly maturing mobile market. It has the highest mobile internet penetration (48%) among the case study countries, driven by the rapid expansion of 4G networks. Mobile operators in India have also invested in deploying NB-IoT networks to support IoT services. For example, Reliance Jio reports 95% NB-IoT population coverage, making it one of the largest NB-IoT networks in the world.

Deployments across use cases

Our research has identified large-scale deployments across a range of use cases. While the maturity of IoT applications varies, the combination of a thriving local IoT ecosystem and strong political support can help ensure deployments continue to scale. Some regions in India are ahead of others in IoT deployment, which often depends on the priorities of the local government driving smart city implementations, as well as regional differences in the level of IoT ecosystem development. Currently, most IoT devices cater to 2G or 4G networks, while a growing role for LPWA technologies and 5G can be expected as network roll-outs continue.

5. Taxmann. (2022). "Customs proposals – A catalyst to Make in India and PLI schemes".
6. Business Standard. (9 July 2015). "Cabinet nod To Rs 1 lakh cr for urban renewal, 100 smart cities to take off".
7. The Rockefeller Foundation. (4 November 2019). "Tata Power and The Rockefeller Foundation Announce Breakthrough Enterprise to Empower Millions of Indians with Renewable Microgrid Electricity". Press release.
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9. Economic Times. (2017). "India signs $175-million loan pact with World Bank to improve water management".
10. Center for Water and Sanitation. (2020). "SaniTab as a monitoring tool".
11. Omar, P. (7 December 2022). "India registered more than 18 lakh EVs, 5,151 charging stations: Nitin Gadkari". *Mint*.
12. Business Standard (2022) "Delhi govt aims to bring 2,000 electric buses in coming years"
13. Times of India (2022) Will India lead the drone delivery industry in the world?

Energy

The government is implementing mass metering programmes. As of March 2022, 15 million smart meters had been procured, but 235 million more are required to meet India's 2025 targets. The requirement to manufacture meters within India has been a major stimulus for the ecosystem. For example, microgrids are in the process of being scaled. Tata Power and the Rockefeller Foundation aim to establish 10,000 microgrids by 2026,[7] and the India Renewable Energy Development Agency recently provided $4.2 million in debt financing to Husk Power to scale their minigrid installations.[8] PAYG solar and clean cooking use cases are established, but have not scaled widely. This is due in part to a government subsidy for liquefied petroleum gas (LPG) that makes PAYG models more challenging.

Water

India is the leader of the case study countries when it comes to deploying IoT solutions in the water sector. The government has conducted a series of trials to show how IoT devices can monitor water supply systems in villages, and the national water monitoring system – India-WRIS – includes IoT deployments.[9] Multiple water treatment and quality management solutions are available in the market, such as end-to-end solutions from providers Smart Terra, Biz4Solutions and RefillBot, while mobile-enabled water ATMs are deployed by companies that include Drinkwell, Janajal and Sarvajal. There is also a drive to deploy smart meters. Municipal water corporations in Chandigarh, New Delhi, Hyderabad, Pune and other cities have all started large-scale smart water meter projects.

Sanitation

Our research found that IoT technologies were being used in several deployments, from smart toilets to septic tank maintenance. For example, local governments in Maharashtra use IoT-based platforms like SaniTab and SaniTrack to monitor waste emptying and transportation.[10] The use of IoT in sewage management is at a more nascent stage. Most initial deployments have been small-scale trials driven by municipalities looking to upgrade existing manual monitoring systems. There are some commercialised offerings for IoT wastewater monitoring, including India-based Fluid Robotics. There are also clear cases of IoT being used in public toilets, for example, GARV Toilets provides prefabricated public toilet units that are manufactured in India. The toilets, deployed in 12 states, integrate IoT devices such as micro programmable interface controllers (PICs), proximity sensors and motion sensors.

Waste management

The most common application is using IoT to optimise routes for waste collection vehicles, along with alerts for waste container fill levels. These solutions use multiple sensors, cameras and GPS systems to gather data that is uploaded to the local government dashboard. Several global smart waste management companies also have a presence in India, often through channel partners. India's EPR guidelines require medium- to large-sized companies producing non-recyclable waste to recover it to reduce environmental damage. This requires waste to be tracked and traced, and companies like ReCircle are meeting this need through digital solutions and minting plastic credits on a blockchain.

Transport

India's Ministry of Housing and Urban Affairs (MoHUA) has focused on developing intelligent transport systems. These systems leverage multiple IoT applications, including traffic management, automatic vehicle detection, fleet management and electronic fare systems. Asset tracking use cases are well established in India, with mobile operators offering a range of services themselves. In December 2022, the Minister of Road Transport & Highways reported that India already has 1.8 million registered EVs and more than 5,000 public charging stations.[11] Many cities have ambitious plans to deploy fleets of electric buses.[12] Drone applications are also on the rise, supported by the recent publication of national drone rules and government ambitions to make India a global drone hub by 2030.[13]

3.2 Indonesia

Policy and market context

The largest market in Southeast Asia, Indonesia boasts notable listings of regional tech giants on the stock exchange and a thriving start-up ecosystem. Until recently, consumer apps and fintech have dominated Indonesia's start-up scene, but this is changing. This shift is happening alongside major government-led initiatives, such as the Making Indonesia 4.0 roadmap and the 100 Smart Cities Movement, which encourage the use of IoT across different industries.

Indonesia scores highly on the GSMA Mobile Connectivity Index (MCI), reflecting a higher level of smartphone adoption, digital skills and locally relevant content and services. Indonesia's IoT deployments benefit from the availability of low-power wide area networks (LPWANs) from multiple providers, including three narrowband IoT (NB-IoT) networks, two public low-range wide area networks (LoRaWANs) and Sigfox Indonesia. There is also an increasing number of device manufacturers supporting IoT deployments, particularly smart meters, although these still rely heavily on imports, especially from China.

Deployments across use cases

IoT deployments are underway across the main utility sectors in Indonesia. In many cases, deployments have been supported by the country's mobile operators, which have advanced IoT strategies. This is demonstrated by the roll-out of LPWANs and the end-to-end solutions offered by mobile operators across multiple use cases. The IoT ecosystem is maturing in other ways as well, with specialist players (e.g. system integrators) and start-ups becoming increasingly involved in IoT deployments.

Despite the potential, deployments in the utility sectors are still relatively small scale. This should begin to change as companies gain more IoT experience and smart city deployments ramp up as municipalities adopt more ambitious plans to leverage IoT solutions to solve various challenges.

14. International Energy Agency (IEA). (2022). "Indonesia county profile". Accessed December 2022.
15. IEA. (2022). "Enhancing Indonesia's Power System".
16. 97% of Indonesia's population had access to electricity in 2020, according to the World Bank.
17. LPG subsidies reached IDR 137 trillion ($9.7 billion) in 2019, according to the International Institute for Sustainable Development (IISD). See: IISD. (2021). "LPG Subsidy Reform in Indonesia: Lessons learned from international experience".
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19. Telkomsel. (2019). "Establishing a Wasteless Homeland: IoT's Contribution in Indonesia's Waste Management Industry".
20. Sriratnasari, S., Wang, G. and Jayadi, R. (2019). "Integrated Smart Transportation using IoT at DKI Jakarta". 2019 International Conference on Information Management and Technology (ICIMTech).

Energy

Grid deployments of smart meters have, until now, been limited to pilots and smaller scale deployments. However, this is likely to change as the state-owned utility State Electricity Corporation (PLN) plans to roll out smart meters covering 79 million people by 2027. Smart meters have been deployed in most solar microgrid deployments in Indonesia, such as those by Electric Vine Industries (EVI) and Inovasi Dinamika Pratama (IDP). At present, solar and wind energy account for only 11% of electricity generation capacity,[14] but deployments can be expected to ramp up as the country aims for 23% renewables in the energy mix by 2025.[15] PAYG SHS or clean cooking products are less common in Indonesia than other case studies, which reflects the country's high electrification rate[16] and heavily subsidised LPG connections.[17]

Water

Our research identified only a few cases of IoT deployments in the water sector. Most IoT activity focused on smart metering and privately installed treatment plants. Even then, Indonesia faces similar challenges as other study countries when it comes to deploying smart meters in the water sector. That is, the low price of water makes it difficult to justify investment in smart metering infrastructure.

Sanitation

Growth in the deployment of wastewater IoT solutions in the private sector is being driven by new regulations aimed at reducing environmental harms. The Ministry of Environment and Forestry (MoEF) introduced a law in 2019 stipulating that 12 industries must implement IoT solutions to monitor the wastewater they generate in real time. A year after introducing the law, the government had installed monitoring instruments at 24 river locations and two effluent discharge sites owned by private companies.[18] This policy has spurred growth in the ecosystem. For example, Lintasarta provides a GSM-based wastewater quality measurement solution that is available on a monthly subscription without upfront costs. Smart public toilets have also been trialled in Indonesia but have yet to scale.

Waste management

While large-scale deployments have yet to emerge in the sector, there is an increasing number of commercial offerings in IoT waste management in Indonesia. For example, mobile operators have adapted their fleet management solution offering to support waste collection. Telkomsel's FleetSight solution enables waste management companies to improve efficiency by combining data obtained from sensors in waste containers and vehicle trackers to optimise collection routes.[19]

Transport

Intelligent public transport systems have been deployed in several large cities in Indonesia. For instance, TransJakarta buses have onboard units that send data on bus position, speed and direction to the city's smart city portal. This real-time data allows travellers to adjust their schedule accordingly.[20] Such systems have emerged as an early 5G use case, as the technology's enhanced bandwidth and lower latency are crucial. In addition, IoT technologies can help Indonesia achieve its goal of becoming a leader in EVs. The government, supported by PLN, aims to build 32,000 public charging stations by 2030. Indonesian companies Wika Industri, Viar and Smoot Motor manufacture EVs, while IoT solutions for real-time monitoring and tracking are also common, particularly for e-bike sharing.

3.3 Kenya

Policy and market context

In 2021, the Kenyan government outlined their Digital Economy Strategy, which aims to increase the contribution of the ICT sector to GDP from 2% in 2020 to 10% by 2030.[21] The Digital Economy Strategy identifies three policy areas to maximise the potential of IoT: i) ensuring allocation and effective management of spectrum resources; ii) increasing efforts to standardise affordable IoT devices and sensors; and iii) supporting the local assembly of end-user hardware.

Kenya is a regional tech leader and attracts many of the continent's start-ups and a good proportion of venture capital (VC) investment.[22] Investments in mobile broadband coverage and strong adoption of mobile money payments have enabled decentralised utility services to scale. LPWA technologies are steadily becoming more available thanks to roll-outs by Safaricom (NB-IoT) and Liquid Telecom (Sigfox). Safaricom is also taking a leading role in driving sector deployments by piloting a wide range of use cases. Both connectivity providers also offer IoT platforms and integration services. One area where there is room for improvement is the affordability of mobile internet services and devices. On the GSMA's Mobile Connectivity Index, Kenya currently ranks lowest among the five study countries on this indicator, thereby limiting mobile internet adoption.[23]

Deployments across use cases

Fast-growing access to mobile and mobile technologies has provided fertile ground for IoT innovation in Kenya. The country is a regional leader in many areas, including the use of microgrid technology and PAYG solar. IoT innovation should continue, spurred by the roll-out of LPWA technologies and a burgeoning IoT hardware ecosystem. Still, significant obstacles to IoT adoption remain. For example, like many utility providers, Kenya's energy and water utilities operate in challenging financial environments that make it difficult to justify investments in new technologies. In other sectors, such as sanitation and waste, hardware costs and a limited local ecosystem have prevented the adoption of IoT at scale.

21. Ministry of Information, Communication, Technology, Innovation and Youth Affairs. (2021). "Digital Economy Strategy".
22. See: https://thebigdeal.substack.com/
23. GSMA Mobile Internet Connectivity Index: https://www.mobileconnectivityindex.com
24. Smith, T. (24 January 2022). "Kenya Power to start smart meter rollout for businesses". *ESI Africa*.
25. Ambani, B. (14 February 2023). "Kenya Power starts process of buying 700,000 meters". *Nation*.
26. AMDA represents 30 companies (encompassing all market leaders) that are operating minigrids across 12 African countries. Data from AMDA. (2021). "Benchmarking Africa's Minigrids".
27. In December 2018, the government launched the Kenya National Electrification Strategy (KNES) – a roadmap for achieving universal access to electricity by the year 2022.
28. White, Z. and Lemasagarai, J. (2022). *Water Utility Digitalisation in Low- and Middle-Income Countries: Experiences from the Kenyan water sector.* GSMA.
29. Safaricom. (3 June 2020). "Smart meters are helping to track water on the internet. Here is how."
30. Microsoft. (5 October 2021). "Upepo Technology Company Limited". Customer stories.
31. Liquid Telecom. (2021). "Connected Water".
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34. Associated Press. (11 February 2023). "Kenya's Electric Transport Plan for Clean Air, Climate". *VOA*.
35. Bboxx. (12 October 2022). "Bboxx partners with Ampersand to provide thousands of taxi e-motos for drivers in Rwanda". Press release.
36. ADS Advance. (1 June 2022). "Skyports and partners launch Kenya's first BVLOS drone deliveries".

Energy

The use of IoT in Kenya's national grid remains limited. However, Kenya Power has recently deployed smart meters to 55,000 SME customer connections as part of a World Bank-funded project[24] and, in February 2023, issued a tender for another 700,000 with requirements for local manufacturing.[25] Kenya is the regional leader in microgrid deployments. Two-thirds of the microgrids identified by the Africa Minigrid Developers Association (AMDA) are in Kenya,[26] and IoT is a key part of Kenya's energy strategy.[27] This has contributed to the rise of specialist companies, such as SteamaCo, which has built IoT platforms specifically for the energy sector and decentralised models. Kenya has also pioneered the use of PAYG SHS to provide cost-effective energy solutions, and IoT-enabled PAYG models are being replicated in other sectors, such as water (CityTaps), irrigation (SunCulture) and clean cooking (M-Gas and SimGas).

Water

Various IoT trials have been completed in the water sector, with many leveraging the available LPWA networks. Safaricom's NB-IoT network has been used for smart meter pilots in Kisumu,[28] Embu[29] and Eldoret,[30] among other cities, and has led to an IoT product line for water. Additionally, CityTaps has leveraged LoRaWAN connectivity for their smart meter solution, and Liquid Telecom has demonstrated how their Sigfox network, which covers 90% of Kenya's population, could be used for a range of solutions in the water sector using hardware from Kamstrup.[31] Smart meters have been deployed by various utilities, but usually focus on large water consumers, such as kiosk providers and businesses.[32] Providers such as Maji Milele are also providing water ATMs independently and in partnership with utilities and other providers.

Sanitation

IoT activity in the sanitation sector has been concentrated in and around Nairobi's informal urban settlements. For example, Mobile Alert Toilets built their own custom-made sensors and software for fill level monitoring, which cost roughly $145 per unit.[33] However, it was ultimately unable to scale operations to the level needed to reduce sensor costs, so it stopped using the technology.

Waste management

Of the five utility sectors in Kenya, IoT is least prevalent in waste management. The ecosystem is nascent with few local solution providers or hardware makers, forcing suppliers to look outside Kenya for solutions. For example, Kenyan waste management company TakaTaka Solutions recently announced a partnership with Evreka, a global software-as-a-service (SaaS) company, to provide smart waste management solutions. This partnership is Evreka's first move into African markets.

Transport

The transport sector has emerged as a key vertical for mobile operator IoT strategies in Kenya. Fleet management and asset tracking solutions via 2G, 3G and 4G networks are offered by Safaricom and Airtel. Liquid Telecom offers similar solutions, having deployed their Sigfox network across major transport routes in the country. This is supported by a growing ecosystem of Kenya-based hardware and software providers, including Navitrac, Numeral IoT, Safetrac Limited and Tramigo. Growth in the sector underlines the importance of transportation to the Kenyan economy – the sector contributes around 8% of GDP. Within public transport, efforts have focused on using IoT to improve safety (e.g. Smart Matatu) and connect point-of-sale terminals on buses (e.g. Mobitill Transit). EVs are an emerging sector, with Kenyan start-ups like Roam, Basi-go and Kiriev introducing EV manufacturing and supply, as well as pay-as-you-drive financing. Rwanda-based EV manufacturer Ampersand has also recently launched operations in Kenya,[34] partnering with Bboxx to address the financing barrier.[35] Additionally, the first beyond visual line of sight (BVLOS) flight certification was just issued for a drone delivery service, paving the way for the deployment of other use cases.[36]

3.4 Nepal

Policy and market context

There is an increasing push to accelerate digitisation in Nepal. This is led by government policy, including the adoption of IoT technologies across the utility sectors. Key ministries are publishing strategies and frameworks to guide digital adoption, including the Digital Nepal Framework (DNF), the Government of Nepal's overarching strategy; the Nepal Electricity Authority's (NEA) Digital NEA strategy, which outlines the government's ambition to deploy a smart grid and smart meter technologies; and the Ministry of Water Supply and Sanitation's Development Plan 2016–2030, which includes "Innovation and Technology Adaptation" as a key pillar.

For these policies to reach their potential, Nepal will need to make progress on many of the dimensions important to IoT deployments. There are no LPWA[37] networks in the country and one in five people still live in areas without 4G coverage. Furthermore, mobile operator strategies are still largely geared towards the consumer segment and smartphone-based services. Important players also have a small presence in the IoT ecosystem, such as system integrators and local hardware providers, which means IoT start-ups must either take on these responsibilities themselves or form partnerships with international companies. One positive is that Nepal's mobile penetration (68%) is relatively high compared to regional and income group peers, providing innovators developing IoT solutions the opportunity to use technology that work with SMS or USSD.

Deployments across use cases

Our research found evidence that IoT technologies were being deployed across Nepal's utility sectors. While most projects are still in early stages, there are plans to scale up deployments in several areas over the next few years. The development sector, in particular the Asian Development Bank (ADB), has been key to accelerating the use of IoT. There is also a growing number of start-ups and other private sector companies accelerating IoT adoption in Nepal.

However, there are still challenges to be resolved, particularly the procurement of affordable hardware. The lack of LPWA networks is a clear barrier to IoT deployments in some areas (e.g. smart water metering), while connectivity needs to be enhanced to support drone applications. There is also more work to do on the policy side, an area where Nepal lags other countries. For example, IoT deployments in Nepal have been delayed because the Nepal Telecommunications Authority (the regulator) is still working on their numbering plan.[38]

37. For a detailed discussion of network specifications and their attributes, see: GSMA. (2023). *IoT for Development: Use Cases Delivering Impact*.
38. Nepali Telecom. (2022). "NTA Allows M2M SIM Cards for CAAN and DHM".

Energy

The adoption of IoT in Nepal's energy sector is driven by the NEA, the state-owned utility company that provides electricity to around 4.8 million homes. The NEA is working closely with the ADB to modernise Nepal's electricity grid. Deployments of smart meters in the hundreds of thousands have begun, with the ADB estimating that it will cost $500 million to deploy five million smart meters in Nepal. The sector has also seen microgrid deployments, which are particularly important in remote areas where grid extensions are a challenge. For example, minigrid provider Gham Power has deployed thousands of systems, impacting the lives of more than 30,000 people.

Water

IoT technologies are beginning to play a role in network monitoring and control, as demonstrated by the use of supervisory control and data acquisition (SCADA) software in the Melamchi Tunnel construction. However, smart water meters have yet to be installed in households. The absence of LPWANs in Nepal is one reason for this. Without low-power networks, smart meter batteries need to be replaced sooner, undermining the business case. Start-ups also have a role to play in helping water providers meet their non-revenue water (NRW) targets. For example, the GSMA is supporting Diyalo to develop and pilot IoT solutions for the water sector.

Sanitation

IoT adoption in the sanitation sector is limited in Nepal. The only IoT deployment identified was a small number of smart toilets in the Kathmandu Valley operated by Aerosan Toilets. They have constructed seven toilets with sensors to automate flushing and cleaning. The solution services 1,500 to 2,000 customers per day at a charge of Rs 15 ($0.10) to use the facilities.

Waste management

The use of IoT for waste management in Nepal has largely been centred in Kathmandu where municipalities have experimented with smart bins that monitor temperature and air pollution levels. Mobile apps and digital platforms are likely to play a more important role in improving citizen engagement with waste collection and segregation in the next few years. While IoT has yet to play a major role, there are several Nepal-based waste management organisations (e.g. Blue Waste to Value, Doko Recyclers and Khaalisi.com) that could likely benefit from deployments.

Transport

The use of IoT solutions in Nepal's transport sector has mostly centred on the use of drones for deliveries. This is largely driven by the challenges of transporting goods on the ground in Nepal. While connectivity can be a barrier to drone deployments, progress is being made in other areas, such as building technical expertise and developing specialised hardware, including by local companies such as Prokura Innovations. Other IoT applications that could improve the delivery of goods are much more limited, such as asset tracking. This should begin to change, however, as there are signs that mobile operators are starting to develop their IoT strategies. For example, Ncell recently launched a fleet management solution. Asset tracking has similar connectivity requirements and is likely to be another early use case for Nepalese operators, with existing networks capable of supporting these applications.

3.5 Nigeria

Policy and market context

Nigeria is home to the largest mobile market and economy in sub-Saharan Africa, representing a significant opportunity to scale IoT solutions in the region. Despite the overall size of the market, digital payment penetration remains low and is among the lowest of the case study countries. The federal government has implemented large-scale metering programmes that are driving adoption in the sector, however. These programmes include government-backed loans to local facilities for energy companies to purchase the meters and develop their manufacturing capacity.

One of the main barriers to IoT adoption in Nigeria is mobile and mobile internet penetration, which is also the lowest of the five case study countries. At the end of 2021, 63% of Nigerians living in rural areas were not connected to mobile internet, compared to 40% of people living in urban areas.[39] Efforts to extend mobile broadband coverage, underpinned by the use of refarmed 900 MHz spectrum, should aid mobile internet uptake in the next few years. There are a growing number of LPWA technologies in Nigeria. For example, MTN offers NB-IoT services, IoT Africa Networks provides Sigfox coverage and Internet Services Nigeria (ISN) and Nova Track Limited offer public LoRaWAN services. However, coverage of these LPWA technologies is still largely limited to Lagos.

Deployments across use cases

The energy and transport sectors are leading the roll-out of IoT solutions in Nigeria. Both sectors have had multiple deployments across the focus areas, reflecting growing interest from a range of private and public sector organisations. However, IoT is playing a more limited role in delivering water, sanitation and waste management services. The latter is reflective of a nascent ecosystem where mobile operators and LPWA providers are focused on a narrower set of use cases, namely smart metering and asset tracking. Financial inclusion in Nigeria is also relatively low, with just over half of Nigerians using formal financial services as of 2020.[40] Limited financial inclusion is a key constraint for many PAYG-based solutions. However, recent regulatory changes that allow mobile money are likely to change this, and IoT-enabled PAYG solutions themselves can drive financial inclusion.[41]

39. GSMA. (2021). *The State of Mobile Internet Connectivity 2021*.
40. EFInA. (2021). *Key Findings: EFInA Access to Financial Services in Nigeria 2020 Survey*.
41. Mastercard. (May 2018). *Pay-As-You-Go and the Internet of Things: Driving a New Wave of Financial Inclusion in the Developing World*.
42. Bauer, G.K. (17 July 2019). "Why off-grid energy providers are increasingly paying attention to urban areas – insights from the DRC and beyond". *GSMA Mobile for Development Blog.*
43. Utomi, J.M. (25 March 2022). "World Water Day 2022 and Lagos' acute water scarcity". *The Guardian*.
44. Akinwa, J. (16 February 2022). "What if you could control water?" IoT Africa Networks.
45. Thomas, E. (19 May 2022). "Virridy contracted by the World Bank to partner with WaterAid Nigeria". Virridy.
46. The smart sanitation economy is defined as a digitised sanitation system that optimises data for operating efficiencies, maintenance, consumer use and health information insights.
47. Toilet Board Coalition. (2020). "Sanitation Economy Markets Nigeria".
48. Afolalu, A. et al. (December 2021). "Development of Smart Waste Bin for Solid Waste Management". *International Journal of Sustainable Development and Planning,* 16(8), pp. 1449–1454.
49. Njoroge, B. (14 December 2021). "Enabling Government-Innovator partnerships in Lagos: Insights from our workshop". *GSMA Mobile for Development Blog*.
50. Jones, Y. (28 April 2022). "The role of digital innovation in solving the urban mobility challenge in Lagos". *GSMA Mobile for Development Blog.*

Energy

There is strong demand for IoT solutions in Nigeria's energy sector due to recent government initiatives. The Meter Asset Provider (MAP) programme was launched in 2018 and the National Mass Metering Programme (NMMP) in 2020. These two programmes aimed to install 6.5 million meters by the end of 2022 and have stimulated local manufacturing. For example, MOJEC established a plant in Nigeria with a production capacity of 1.5 million meters annually. Nigeria also has a significant off-grid market in both rural and urban areas, for example, more than 60% of Lumos' customers live in urban or peri-urban areas.[42] IoT-based PAYG solutions are becoming increasingly prevalent in other areas, such as clean cooking. Microgrids are also becoming more prevalent as they play a key part in Nigeria's ambitious rural electrification programme. IoT is a key enabler of the vital results-based financing component of the programme.

Water

Our research identified only a few IoT deployments in the water sector, all of which were small scale. Most Nigerian water supply connections are not metered, although there is growing interest from private sector companies in deploying smart meters, such as IoT Africa Networks (the exclusive Sigfox distributor in Nigeria).[43] Through a partnership with hardware provider Kamstrup, they are deploying smart water meters to help water utilities and private sector vendors minimise water losses.[44] There have also been pilots to remotely monitor critical infrastructure, such as a recent deployment by Virridy and the World Bank that uses low-cost satellite-connected sensors.[45]

Sanitation

Our research found little evidence of IoT being used to support the delivery of services in the sanitation sector. This is despite a 2021 Toilet Board Coalition report that estimated Nigeria's smart sanitation economy could be worth $2.6 billion by 2030, with sensor-fitted toilet technologies accounting for half this total.[46,47]

Waste management

IoT has played only a limited role in Nigeria's waste management sector to date. Start-ups like GIVO and Scrapays are using IoT devices to support their circular economy solutions. Other IoT applications, such as tracking waste collection vehicles and monitoring waste containers, are still in the development phase.[48] There are several obstacles to commercialisation that must be overcome. For example, there is a perception among some public sector stakeholders that the data collection associated with IoT and some other digital solutions is an expensive and secondary venture that does not fall within their core service mandate.[49]

Transport

Nigerian mobile operators have focused most of their IoT efforts on providing connectivity. There are some exceptions, however, such as the transportation sector where MTN offers a range of fleet management solutions, including asset tracking, vehicle tracking and driver management. These IoT use cases are among the most mature in Nigeria and are driving interest from a range of other players, including public LoRaWAN providers (e.g. Nova Track Limited) and local IoT start-ups (e.g. Gricd). IoT is also playing a role in Lagos' Bus Rapid Transit (BRT) service and generating data for transport planning.[50] The use of IoT to enable delivery drones and support EV infrastructure is less mature. Nigerian start-ups such as Arone and Lifebank tested the use of drones for medical deliveries, but have since shifted their focus.

4 Trends and triggers across markets

With growing pressure on limited resources, utility providers are seeking new ways to match supply and demand, harness cleaner energy sources and reduce costs. Evidence from the case study markets shows that IoT will be pivotal to achieving these goals. With limited resources, it is important that city authorities prioritise deployments with either significant social or economic returns or, in the best case, both. Mobile operators may also need to focus on specific verticals to develop their IoT capabilities and offering. There are clear cases where both sets of objectives can be aligned. The following section discusses some of the key findings from across the use cases and the trends likely to shape deployments in the coming years.

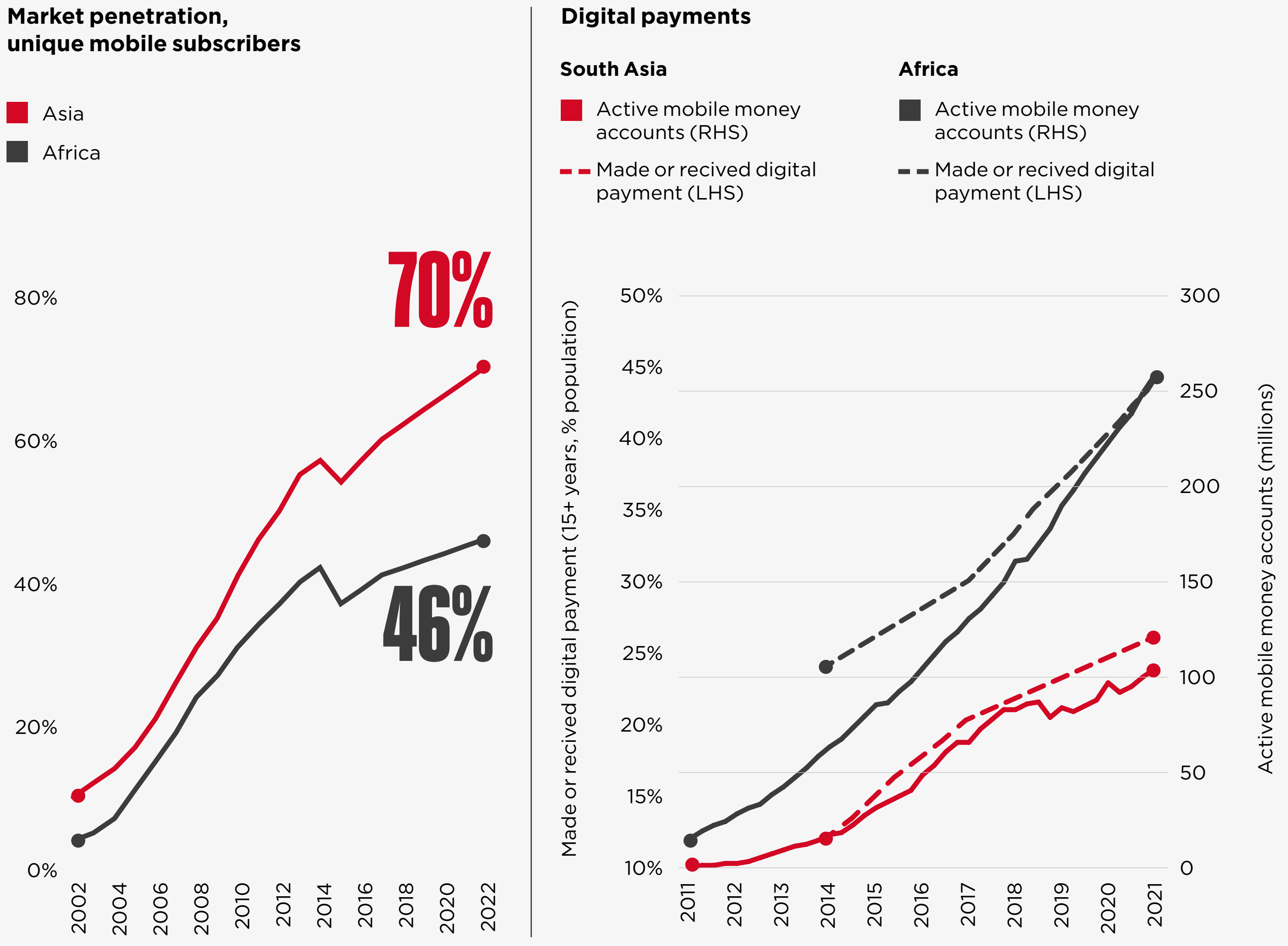
4.1 The IoT ecosystem

Connectivity and LPWA network availability

A key prerequisite for practically all digital technology is connectivity. It is difficult to understate the phenomenal rise in the use of digital technologies over the past two decades. Mobile subscriber rates in Africa and Asia are rising rapidly alongside the use of digital payments and mobile money (see Figure 7). This acceleration is an excellent proxy for digital development and is a signal of emerging opportunities in new markets.

Figure 7

Unique mobile subscribers and mobile money transactions



Source: Authors analysis of GSMA intelligence data for mobile subscriber and mobile money data, and authors analysis of World Bank Findex database for digtial payments data.

2G, 3G, and 4G networks are widely used and available. The pace of 2G/3G network shutdowns is increasing as mobile operators optimise operations and costs and reframe spectrum for 4G and 5G. Mobile operators in South and Southeast Asia are likely to retire legacy networks before their counterparts in sub-Saharan Africa due to the higher penetration of 4G services in their regions. Momentum for 5G is building across regions, with commercial 5G mobile services launching in four sub-Saharan African markets and five LMIC markets in South and Southeast Asia. This figure will increase in the coming years as several mobile operators in LMICs have formally announced plans to launch 5G. The uneven roll-out of 5G has consequences for different IoT use cases, but given the nature of utility IoT use cases, the more significant are developments in LPWA networks.

With the exception of Nepal, multiple LPWA technologies have been launched in the case study markets. This is an important step in scaling IoT solutions like smart metering and asset monitoring, which require low data rates and infrequent transmissions to extend battery life. There is significant variation in the level of LPWA coverage in the case study markets. While there is almost nationwide NB-IoT population coverage in India and high levels in Indonesia, NB-IoT is limited to only a small number of sites in Nigeria. Other LPWA technologies are also not universal. Sigfox covers more than 85% of the population in Kenya but is much lower in other markets. LoRaWAN networks have gained traction in Indonesia but remain nascent elsewhere. The differences in LPWA availability add to the due diligence stakeholders must conduct when researching local IoT markets. It also makes it harder to build economies of scale in terms of hardware production, as different markets use different connectivity technologies for the same use cases. For example, 2G, 3G, 4G, NB-IoT, Sigfox and LoRaWAN have all been used by at least one utility provider for smart metering in the case study markets.

Hardware

The limited availability of low-cost hardware remains a key barrier to scaling IoT deployments in the case study markets. Our research highlights where public and private stakeholders are developing manufacturing capabilities to make IoT solutions more affordable and capture more value.

A key trend identified in the research is that large-scale procurement of centralised utility services, combined with enabling procurement policies, can stimulate the market. Examples from Nigeria, India and Indonesia highlight this opportunity. In each of these markets, government policy has been a strong factor in stimulating the ecosystem. In Nigeria, companies such as MOJEC are already manufacturing smart meters at scale. India has also ramped up smart meter manufacturing capabilities alongside efforts to develop hardware for other utility use cases, such as water supply network monitoring. Building these kinds of capabilities takes time and requires both significant funding and technical skills.

For comparatively smaller markets, such as Kenya and Nepal, it will likely be more difficult to develop IoT hardware manufacturing capabilities given the lower potential for economies of scale. However, as regional manufacturing capacity develops, devices may be able to be procured at lower costs, particularly as companies from larger markets look to expand into similar contexts. All the case study markets are likely to continue relying on China, Europe and the US for some IoT hardware, such as chipsets, which require much higher levels of skill and investment.

Applications and platforms

End-to-end providers of IoT solutions are taking a holistic approach to support deployments in the case study markets. For example, cloud vendors are combining cloud infrastructure with IoT platforms and other capabilities to support deployments. Mobile operators are also in the game, approaching enterprises from a connectivity perspective and adding IoT platforms, security and data analytics to their propositions.

Several connectivity providers in India and Indonesia, along with Safaricom and Liquid Telecom in Kenya, are offering a wider range of IoT solutions. This includes curated ecosystems of hardware, platforms and applications that address the needs of enterprises of different sizes. Connectivity providers are particularly focused on high-volume segments (such as smart metering and asset tracking), which offer greater opportunities to generate meaningful revenue. Their support is playing a vital role in supporting utility providers and IoT innovators, bringing additional IoT expertise and resources to scale solutions.

However, not all connectivity providers have the resources or technical capacity to position themselves as end-to-end IoT orchestrators. Some may lack the necessary scale or partners (e.g. cloud providers and system integrators) to develop these competencies. Others may operate in markets where IoT demand or mobile internet adoption remain low. The involvement of these connectivity providers in the IoT market is, therefore, focused on solving basic connectivity challenges. This can be detrimental to utility providers and IoT innovators aiming to expand their reach, given the lack of viable alternative partners in nascent IoT markets.

4.2 The utility sectors

Energy

All the case study markets have announced plans for mass deployments of smart energy meters to reduce transmission and distribution losses and pave the way for tariff innovation. Millions of smart energy meters have already been installed in India and Nigeria with the support of government policy, funding and growing domestic manufacturing capacity. These enabling factors are not as present in the other case study countries.

IoT is also playing a significant role in other areas of the energy sector, such as supporting the deployment of solar microgrids, which are gaining traction. Solar microgrids can help to overcome some of the technical and economic challenges associated with extending the electricity grid to remote locations, as in Indonesia and Nepal. They are also cost-effective; off-grid energy has been identified as the least-cost electrification option for 41% of those without power to 2030.[51] In Kenya and Nigeria, government funding from rural electrification programmes has been central to these deployments.

The rise of solar microgrids has consequences for other IoT use cases, too. As the energy mix evolves, utilities will require a smarter grid system to manage energy generation from a wider range of smaller sources. IoT-enabled smart grid implementations are still nascent in the case study markets, with limited evidence of deployments beyond small-scale trials. This reflects the technical challenges and costs associated with smart grids, as well as the infancy of smart meter deployments, which are often the first step in improving the visibility of reliability events on energy grids.

In comparison, the installation of IoT-enabled SHS and clean cooking products is much easier, and the established SHS market already provides power to hundreds of millions of people. The World Bank estimates that 270 million solar energy kits have been sold since 2010, providing more than 490 million people with energy services, and the total off-grid market is currently valued at $2.8 billion annually.[52] These use cases have seen significant traction in Kenya and Nigeria where using mobile phones to make services more accessible and affordable through mobile payments and IoT is an established model. Start-ups have therefore used partnerships with mobile operators to expand the reach of their IoT-enabled products and services. In other markets, notably India and Indonesia, government subsidies for LPG suppress demand for PAYG clean cooking solutions. A potential solution is to link subsidy delivery with actual consumption through digital technology, which could pave the way for smarter and more targeted subsidy delivery while also opening the market to new players in cooking services.[53]

Water

In the five case study markets, smart water meters have been deployed at a slower rate than smart energy meters. This is due in part to the challenge of generating a return on investment in IoT in the water sector. While smart meters help to address water losses, interviewees in multiple countries highlighted that the low costs of producing water, combined with the relatively high cost of smart meter hardware, make investments harder to justify. However, this business-as-usual cost-benefit analysis is unlikely to hold in the face of climate change. A quarter of the world's population live in countries already facing "extremely high" water stress,[54] and business leaders consistently rank water crises in the top five global risks by impact.[55] When the focus shifts to managing a scarce resource and preventing water crises in cities – as dramatically illustrated in Durban, South Africa in 2018 and Chennai, India in 2019 – the costs of these deployments need to be weighed against

51. World Bank. (2022). *Off-Grid Solar Market Trends Report 2022: State of the Sector*.
52. Ibid.
53. White, Z. and Bauer, G.K. (25 March 2021). "Smarter subsidies and digital innovation: Implications for utility services". GSMA Mobile for Development Blog.
54. World Resources Institute. (6 August 2019). "Release: Updated Global Water Risk Atlas Reveals Top Water-Stressed Countries and States".
55. Based on the World Economic Forum's Global Risk Perception Survey. See: http://www3.weforum.org/docs/WEF_The_Global_Risks_Report_2021.pdf

the environmental, economic and social damage caused by water scarcity, rather than the costs of producing water in times of plenty.

Smart water meter deployments are also complex from a connectivity perspective. By definition, smart energy meters can be connected to power sources and have less stringent battery requirements than smart water meters. Water meters, on the other hand, often require batteries, and battery life is a key determinant of the cost-effectiveness of a deployment. LPWA technologies are more important for smart water meter deployments, but availability varies across LMICs.

Still, smart metering remains the most common IoT use case in the water sector. Most water utilities in the five case study markets have not yet introduced sensors to their distribution networks, which would give them a better view of water flow throughout the system, nor have they experimented with using IoT for other use cases, such as water treatment and purification. Interviewees cited challenges such as a lack of purpose-built devices for these applications, with current deployments relying on repurposed industrial sensors instead. However, the automation of water supply network monitoring has started to gain traction in India, where water scarcity demands that resources be managed more efficiently. It is encouraging that as attention shifts to managing water risks in the face of climate change, there is a healthy pipeline of innovative companies developing more effective management solutions. Financing and political will are more often barriers to deployments than technological capability.

Sanitation

The use of IoT in the sanitation sector is still limited in the five case study countries. Several countries have experimented with IoT solutions to understand public toilet usage and optimise maintenance. For example, sensors have been used to monitor toilet occupancy, automate flushing and handwashing and alert maintenance teams of poor toilet conditions. The popularity of this use case is due to the availability of low-cost hardware, ease of installation and a wide range of suitable networks (2G, 3G and 4G networks, as well as LPWA technologies, can all be used).

More advanced applications, such as placing sensors inside toilets and pit latrines to monitor fill levels and optimise waste collection, were less common. Kenya was the only case study market where this type of IoT application was found. However, the deployments faced several challenges. For example, pit fill level monitoring sensors are complex to install and incur additional costs due to the protective casing needed to guard against the corrosive environment. The limited number of deployments also means there are few device suppliers, compelling local start-ups to develop their own solutions. Connectivity is also a challenge. Placing sensors underground means LPWA coverage is required to ensure reliability and extend battery life.

The use of IoT for wastewater monitoring is also limited in most of the case study countries. Where solutions have been deployed, policy has played a significant role. For example, the introduction of regulation requiring industries in Indonesia to automate wastewater monitoring has led to several deployments. This has been enabled by Indonesia's relatively advanced IoT ecosystem, particularly in terms of connectivity and digital skills, which has helped local solution providers build wastewater monitoring capabilities quickly.

Waste management

Overall, the five case study countries have been slow to adopt IoT solutions in the waste management sector. India has the most deployments of smart sensors to locate waste containers and optimise waste collection, while companies in Kenya have experimented with similar technology at a smaller scale. IoT-enabled devices are also aiding recycling initiatives in several of the case study countries, but these solutions have limited reach.

The slow adoption of IoT in the sector reflects hardware limitations. The smart waste bins that have been deployed cannot measure waste volume by material type, which could significantly improve waste planning and reduce the amount of manual sorting. Therefore, the cost savings enabled by current implementations are limited, increasing the importance of public funding to support IoT deployments. For example, India's Smart Cities Mission and SBM 2.0 policies have helped local municipalities invest in IoT solutions in the waste management sector. Countries with smaller budgets have prioritised investments in other areas, such as smart energy meters, which are seen as having potential for greater impact.

Consequently, the IoT ecosystem for waste management solutions remains relatively nascent in most case study countries. There are a small number of local start-ups providing solutions, primarily using components sourced from abroad. India is the exception, with several local companies providing hardware and system integration capabilities. The small budgets available for IoT in waste management limit the incentive for mobile operators to play a role in the sector beyond providing connectivity. However, some mobile operators, such as Telkomsel, have demonstrated how their fleet management solutions can be adapted to support waste collection vehicles, indicating a growing interest in smart waste management.

Both the waste management and sanitation sectors are likely to benefit from innovations in asset tracking. This is due to the nature of the value chains – independent operators collect waste from households, after which the waste is centralised for processing/treatment. It is likely that many asset tracking solutions will have a place in waste management and sanitation services, especially when combined with digital platforms.[56]

Transport

Asset tracking is among the most mature transport IoT use cases in all the case study markets. There are several reasons for this. First, the hardware is widely available due to the maturity of asset tracking globally and the similarity of devices across different countries. Asset tracking equipment is also relatively easy to install, which means solutions can be deployed without companies and employees needing advanced technical skills. Second, contractual negotiations often only involve private sector companies, which can shorten the time to market for solutions. Furthermore, while asset tracking can be enhanced by some LPWANs, it works well with 2G and 3G networks, which are more widely available than LPWA alternatives. There are examples in each of the case study markets of connectivity providers offering end-to-end IoT solutions for the transport sector.

Other IoT use cases in the transport sector are yet to be deployed at scale in the five case study markets. This should begin to change, particularly in India and Indonesia where 5G roll-outs are accelerating quickly and enabling new applications, such as video surveillance for smart public transport systems and drones for deliveries and traffic management. In addition, the drive to lower carbon emissions will lead to additional policy incentives to accelerate the roll-out of EVs and related charging infrastructure that integrate IoT technologies. While EV deployments are still in an early stage, there are many, and increasingly well financed, start-ups and established companies deploying IoT-enabled solutions and introducing EV manufacturing. Our recent report, Digital Innovation and Transport in Africa, found that transport and logistics is the third largest sector in terms of deal value for tech-focused investment on the continent, attracting $1.4 billion in investment in the past four years. While deployments at scale are nascent at this stage, it is clearly a growing sector.

PAYG use cases across sectors

PAYG is particularly important in the utilities sectors, as often asset financing options need to be part of solution offerings to make deployments feasible. PAYG solar has emerged as the dominant use case and the sector has grown rapidly, attracting billions in commercial investment. The technology underpinning PAYG solar can be repurposed for a huge range of different assets and use cases. Additionally, companies operating have acquired deep expertise in asset financing for low-income consumers, and their customers have been able to build credit/ repayment histories. The combination of these two factors is allowing these companies to now offer a much wider range of products and services.[57] It is also the case that in many LMIC markets, those marketing solutions have come to realise that providing financing alongside goods is the most viable route to deep market penetration. These products beyond solar represent a huge commercial opportunity. The addressable market for off-grid fans, televisions and refrigerators alone is estimated to be worth over $25 billion by 2030.[58]

The GSMA Innovation Fund has a long history of supporting the emergence and growth of the PAYG sector. Figure 8 outlines the evolution of our support to the sector. Importantly, PAYG use cases highlight the value of uniting payments and consumption monitoring. This offering is the backbone of many innovative financing models based on revenue share, as well as those that rely on consumption subsidies or results-based financing.

56. White, Z. (20 April 2022). "Digital platforms for utility services – emerging trends and what comes next". *GSMA Mobile for Development Blog*.
57. For more details on PAYG model see CGAP (2018). "Strange Beasts: Making Sense of PAYGo Solar Business Models"
58. Efficiency for Access (2019) "2019 State of the Off-Grid Appliance Market Report"

Figure 8

GSMA Innovation Fund support for PAYG providers

2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022

Solar home systems

- **M-KOPA**, Kenya
- **Mobisol**, Rwanda
- **Fenxi**, Uganda
- **PEG Africa**, Ghana
- **Lumos**, Nigeria
- **D.Light**, Haiti
- **SNV**, Benin
- **Village Infrastructure**, Vanuatu
- **Brighterlite**, Myanmar
- **Ecoenergy**, Pakistan
- **Solarworks**, Mozambique
- **Smarter grid**, Nigeria
- **Orange**, Madagascar
- **Afghan Wireless**, Afghanistan
- **Easypaisa**, Pakistan

Micro-grids

- **Solashare**, Bangaldesh
- **KAMWORKS**, Cambodia
- **Devergy**, Tanzania
- **Gham Power**, Nepal
- **EVI**, Indonesia
- **Electricité de Madagascar**
- **EarthSpark**, Haiti

PAYG energy in humanitarian settings

- **Bboxx**, DRC
- **Altech**, DRC

Cooling

- **Koolboks**, Nigeria

Solar irrigation

- **SunCulture**, Kenya

Smartphones

- **Vitalite**, Zambia
- **Zonful Energy**, Zimbabwe
- **Widenergy**, Zambia

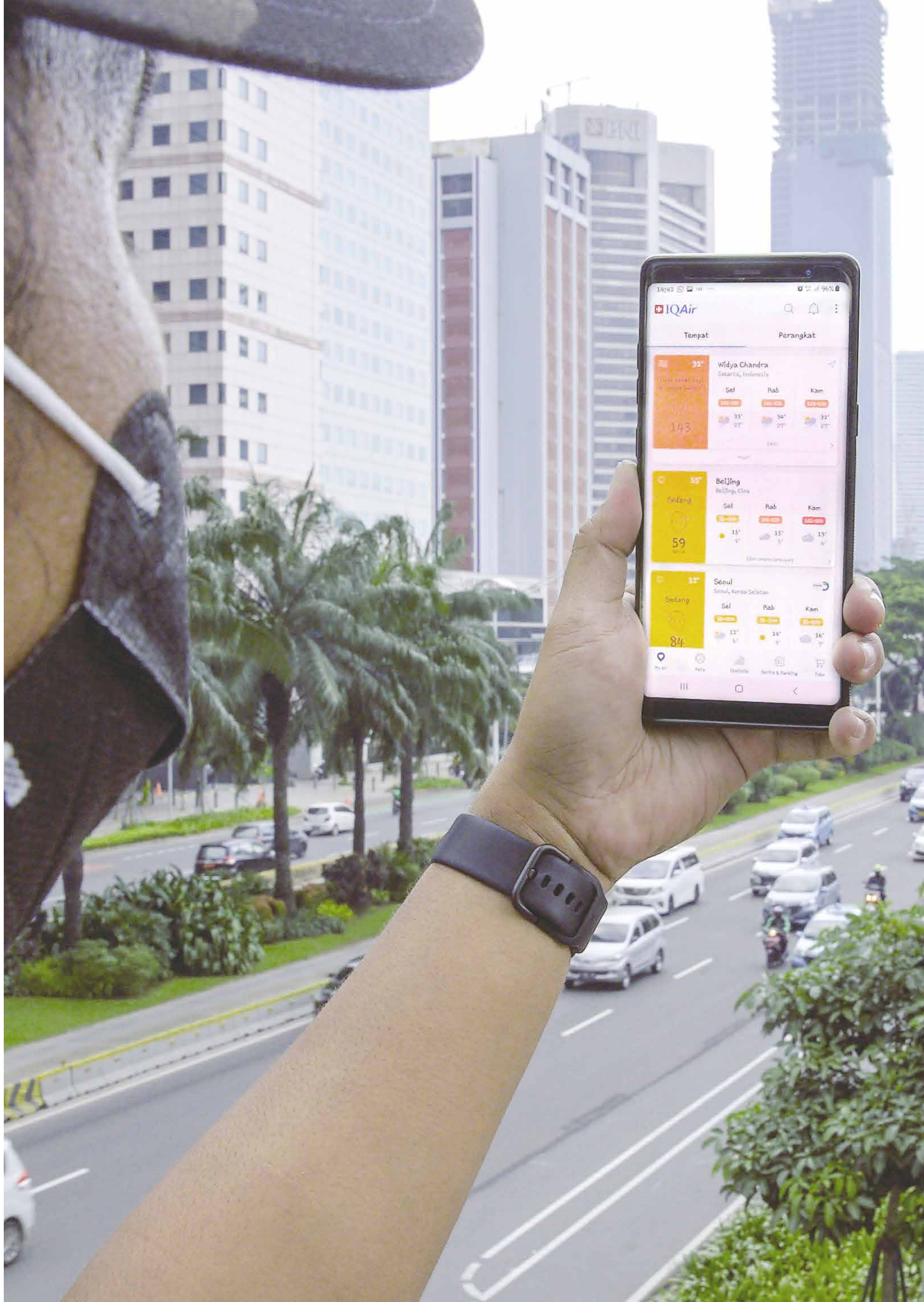
Clean cooking

- **Kopagas**, Tanzania
- **Simgas**, Kenya
- **ATEC**, Bangladesh
- **Powerstove**, Nigeria

Water services

- **CityTaps**, Niger
- **Safe Water Network**, Ghana
- **eWATERpay**, The Gambia
- **Drinkwell**, Bangladesh
- **JanaJal**, India

Source: The GSMA Innovation Fund



5 Accelerating adoption

To maximise the potential of IoT opportunities in the utility sectors, the following actions are likely to support adoption across markets. These recommendations work in concert with those published in the companion report 'IoT for Development: Use Cases Delivering Impact'.

Mobile operators

- **Develop strategies to avoid competing on price alone**. Mobile operators need to build other assets, such as platform and application capabilities, to defend their core connectivity business against increasing competition from IoT MVNOs, as well as Sigfox and LoRaWAN providers. This is particularly relevant in utility sectors, where price is often a critical factor and Mobile operators compete for long-term contracts.

- **Consider the co-benefits of deployments**. The benefits of supporting the digitalisation of utilities extend beyond the incremental revenue from new contracts. For example, deploying smart meters to enable rural electrification can create opportunities to increase the use of mobile payments, enhance smartphone adoption and boost local economic development. These benefits should be factored in when negotiating with utilities.

- **Educate customers about IoT opportunities**. Low customer awareness about IoT solutions and their benefits is a major barrier to IoT adoption in the utility sectors, particularly in nascent markets. Mobile operators have an important role to play in educating customers, such as utility companies. Customer roadshows and industry whitepapers can be relatively inexpensive ways to build customer knowledge, while targeted above-the-line campaigns can help to reach wider audiences.

- **Build utility deployments into enterprise IoT strategies and invest in relationships**. In African markets, utility deployments are expected to account for nearly a third of net IoT device additions. This makes it a crucial segment for any mobile operator in the space. Investing in developing relationships with government and the private sector will be essential to realising deployments in the next decade.

Utility service providers

- **Conduct pilots to learn and develop capabilities**. The GSMA's experience with supporting innovation and our research with water utilities highlight the importance of viewing digitalisation as a process. IoT deployments rest on a broader digital foundation, and utility providers should make progressive investments in developing their capabilities. Since IoT is still a frontier technology for many utility providers, it is important to invest in pilots to develop relationships and capabilities. This can also help to inform the standards and requirements needed to move to larger procurements.

- **Conduct due diligence on connectivity partners**. Choosing a connectivity provider is an important decision, particularly given the array of LPWA technologies available in some markets. In addition to considering the technical capabilities of each option, it is also important to weigh the commercial strengths of potential partners. Due to the size of their operations, mobile operators are likely to be less risky than unlicensed LPWA providers, which have encountered financial challenges in some countries. Still, there are instances of mobile operators scaling back their IoT networks,[59] and utilities must also be aware of any sunset plans for 2G and 3G. This underlines the importance of due diligence.

- **Form procurement partnerships to reduce costs**. In interviews, water and sanitation providers cited cost as the biggest barrier to deploying IoT solutions. Utility service providers in these sectors sometimes lack the scale required to negotiate effectively with suppliers. By documenting their requirements, utilities can enter procurement partnerships with their counterparts in other cities to increase their negotiating power.

- **Look beyond narrow cost-benefit analyses**. Discussions about the benefits of deploying IoT solutions often focus on cost savings and improved efficiencies. However, it is important to

59. Waring, J. (31 March 2020). "Docomo kills-off NB-IoT network". Mobile World Live.

also factor in indirect benefits, such as the boost to the economy from electrification, the lower burden on healthcare systems from improved access to water and sanitation facilities and the environmental gains from the uptick in recycling and reduced water losses. Similarly, deployments strengthen capacity to manage critical issues, from avoiding damaging periods of water scarcity to proactively monitoring public health. Too narrow a conception of the possible benefits will limit ambition.

Innovators and solution providers

— **Focus on core competencies**. Innovators must choose between buying IoT hardware and/ or software or developing it in house. Buying is usually quicker, but building it can enable an innovator to differentiate their IoT solution more easily. Ultimately, the decision to build or buy should align with business resources and capabilities, as well as the potential to generate business value.

— **Seek a variety of partners to diversify risk and build a track record**. While large and established companies like mobile operators and development organisations are obvious partners for IoT innovators, they should not overlook opportunities to collaborate with other innovators. This is particularly important in nascent IoT markets where the ecosystem is less developed and there is likely to be skill shortages. The collaboration between Diyalo and Gham Power in Nepal is a good example.

Policymakers

— **Establish an enabling regulatory environment for IoT**. IoT solutions in utilities and other sectors cannot gain traction without the support of policymakers to develop the IoT market. Some of the most important steps include allocating sufficient spectrum in the subGHz frequency bands for M2M and IoT applications, and formulating national standards and specifications for IoT devices, such as smart meters.

— **Develop skills programmes and training schemes**. The shortage of specialist talent in areas, such as engineering and data science, is a barrier to developing a stronger IoT ecosystem. Policymakers need to take a long-term approach to skills development. This involves improving ICT access and teaching in schools and adding technical programmes to school curricula. Establishing more partnerships between governments, universities and tech hubs can also help to improve skill sets.

Annex 1: **Use cases considered in the research**

Sector	Use case	Description	Benefits	Device(s)
Energy	Smart metering	• Accurately records and automatically transmits energy usage data in real time	• No longer need to send staff to customers' premises to read their meter or rely on customers to report the meter reading themselves • Allows utilities to introduce time-based tariffs to manage demand • Allows for alternative energy planning and modelling • Allows for cost savings, energy theft monitoring, etc.	Meters
	Smart grid	• Tracks the distribution network in real time, providing measurements of voltage sags, swells, interrupt information and other metrics	• Enables energy companies to redirect resources when demand on the grid is increasing • Find and resolve faults more quickly, improving the customer experience • Reduced risk of fines from service level agreement (SLA) breaches	Sensors (e.g. current, voltage)
	Microgrids	• Sensors embedded on solar photovoltaic (PV) installations (e.g. a microgrid run by a smallholder or large-scale solar farm) to monitor production and distribution	• Avoids fossil fuel-derived emissions (mostly coal) • Optimises power consumption at residential and industrial premises by using stored energy (rather than relying on the grid)	Meters, sensors (e.g. current, voltage)
	PAYG cooking and SHS	• IoT-enabled devices include connected LPG cylinders and electromagnetic induction stoves • Solutions collect usage data and relay information to users (e.g. reminders to charge battery, make payments)	• Make services more affordable for poor consumers because they can make micropayments • Enables credit scoring for unbanked users • More effective revenue collection for service providers	Meters, sensors (e.g. temperature), GPS

Sector	Use case	Description	Benefits	Device(s)
Water	Smart metering	• Accurately records and automatically transmits water usage data in real time	• Lower staff costs and improved reading accuracy • Leaks are easier to identify and fix, enabling utilities to reduce their NRW costs • Introduce new services (e.g. a PAYG option for lower income customers) • Provides visibility into water contamination and pH levels	Meters
	Water ATMs	• ATMs automatically dispense water for which customers prepay • ATMs are IoT-enabled, allowing real-time monitoring	• Provides visibility into the volume of water dispersed and number of users • Measures leakage and water quality • Some solutions combine water ATMs with a water treatment solution for purifying water	Meters, connected water purifiers, pH sensors
	Water treatment	• Tracks filter usage to ensure filters are replaced on time to avoid contaminants entering the system • Measures the chemical properties of downstream water	• Helps to prevent compliance issues by keeping alkalization of water within permissible levels and avoiding potential health risks • Reduces system downtime and maintenance	Connected water purifiers, pH sensors, oxidation reduction potential (ORP) sensors
	Supply network monitoring	• Monitors water pressure and flow in pipes to detect leaks and predict bursts • Measures the temperature of the output of the safety valve, which falls rapidly before leakage occurs	• Enables the early detection of faults to avoid unscheduled shutdown and maintenance • Improves uptime of water pipe network	Water flow meter, sensors (pressure, temperature)
Sanitation	Wastewater monitoring	• Placing sensors in sewer lines and waterways to monitor the flow of sewage, breakage and leakage	• Improves understanding of pathogen levels in rivers • Improves understanding of sewage value for upcycling	Sewer level monitoring sensor, acoustic sensor, camera
	Smart toilets	• Provides insights into public toilet usage and cleanliness	• Automates toilet cleaner, reducing maintenance needs	Ambient monitoring sensor, motion sensors
	Pit fill level monitoring	• Use of IoT devices to monitor and send alerts on fill levels and overflows • Can be combined with real-time tracking of service vehicles	• Ensures safer and more efficient disposal of faecal sludge for a cleaner and healthier city	Fill level sensor, vehicle tracker

Sector	Use case	Description	Benefits	Device(s)
Waste management	Smart bins	• Enables the location and fill level of waste containers to be monitored remotely • Often combined with real-time tracking of service vehicles	• When a waste container is almost full, an alert is set to arrange a pickup even before the pre-scheduled time • Understanding the geography of emptying patterns helps to forecast future needs	Trackers (container, vehicle, workforce), fill level sensor, temperature sensor
	Smart recycling	• IoT devices can be used to weigh recyclable waste • More sophisticated machinery can be used to automate waste segregation	• Increases recycling rates • Reduces open degradation of organic waste (and the growth of microorganisms)	Scales, sensors (e.g. ultrasonic, colour), servomotor
Transport	Smart public transport	• Real-time tracking of public transport vehicles allows transport operators and commuters to see where vehicles are • Transport operators can receive additional data on how vehicles are driven	• Passengers benefit from a more predictable and reliable public transport service • Enriches the quality of long-term public transport and urban planning • Onboard cameras can improve driver and rider safety	Vehicle tracker, CCTV cameras
	EVs	• Sensors on EVs to monitor fuel consumption and routing • EV charging point sensors provide location beacons for passing EVs	• CO2 savings from substituting fossil fuels for electricity and embedding sensors in EVs • Charging point sensors avoid wasted emissions from searching for a charging point	Charging point sensors, EV sensors
	Asset tracking	• IoT devices can be attached to shipping containers, trailers, pallets and even individual packages to monitor transportation	• Reduces lost items • Helps companies ensure their products are being transported under the right conditions	Trackers and sensors (e.g. temperature, humidity, moisture)
	Drones for deliveries	• Drones can be used to deliver items (e.g. medical supplies) from one location to another	• Provides a more environmentally friendly and efficient delivery service (in certain conditions) compared with traditional methods	Light detection and ranging (LiDAR) sensors, GPS/ GNSS, gyroscopes, accelerometers

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