GSMA

The State of Mobile-Enabled Climate Technology in Indonesia

GSMA

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Contents

List of figures

List of tables

List of boxes

1 Executive summary

Indonesia faces a unique set of climate change challenges, from extreme flooding to extended drought, changes in rainfall patterns and temperature and sea level rise.

These risks are intensified by a dense population of 270 million people living in hazard-prone areas, and approximately 60 per cent living in low-lying coastal cities. Indonesia is the world's eighth biggest emitter of greenhouse gases (GHGs). Forestry and other land use practices, energy and waste are key contributors.

Since the first national strategy on climate change was released by the Ministry of Environment in 2007, the Indonesian Government has made a series of commitments to reduce GHG emissions and manage climate risks. In 2016, Indonesia submitted a 2030 climate pledge, or National Determined Contribution (NDC), under the Paris Agreement to achieve 29 per cent of reference emissions levels by 2030 with an unconditional target, and up to 41 per cent with international support (conditional target). Recently, the government set an even more ambitious goal to reach net-zero emissions by 2060 or sooner through the 2021 Long-Term Strategy for Low Carbon and Climate Resilience 2050 (LTS-LCCR 2050).

Globally, mobile-enabled technologies have unlocked an array of solutions to enhance climate mitigation and adaptation outcomes while also creating broader social and environmental benefits. Indonesia has seen rapid growth in mobile-enabled services, with seven mobile network operators (MNOs) serving an estimated 185 million unique subscribers and nearly 55 per cent of Indonesians subscribing to mobile internet. Tech start-ups and the digital economy are also growing rapidly, with Indonesia predicted to become the region's largest digital economy by 2025. This technological advancement is also contributing to the growth of climate technology, with notable expansion in renewable energy, energy efficiency, agriculture, waste management and the circular economy.

This report explores the potential for mobile-enabled technology solutions to enhance Indonesia's climate mitigation and adaptation efforts. It presents an overview of the main climate challenges facing the country and examines the potential role of mobile-enabled technology in unlocking novel and innovative responses to climate change. All this centres around three focus areas for climate action in Indonesia: energy, waste and natural resource management.

To create a clear picture of the distribution of climate technology in Indonesia, including where investment is primarily focused, the Mobile Innovation Hub Indonesia team reviewed publicly available literature and compiled a list of 48 examples of technology-enabled climate solutions currently deployed, piloted or in the proof-of-concept stage in Indonesia's energy, waste and natural resource management sectors. The highest concentration of climate technology was found in the energy and waste sectors, with just under half of climate solutions relating to waste. Technologies for sorting and recycling in the waste sector, as well as energy management and natural resource management are some of the most prevalent solutions.

Interviews with stakeholders, including MNOs, mobile infrastructure organisations, government officials and ministries, revealed technical, political and behavioural barriers that are limiting the uptake of mobile-enabled solutions for climate mitigation and adaptation.

Table 1

Key barriers slowing uptake of mobile-enabled solutions in Indonesia

Technical barriers	**The availability of mobile and digital infrastructure and access to affordable and connected devices** Although robust government approaches are making strong headway, there are still regional and remote island locations without sufficient connectivity. When it comes to implementing climate technologies these are important considerations.
Political barriers	**The political, social and ecological decisions and actions affecting climate change decision-making or uptake of mobile-enabled technologies** — **Collaborative environment:** Limited collaboration between governments, the private sector and communities — **Data sharing and management:** Lack of data integration and reliance on manual data collection processes — **Policy and regulation:** Lack of policy incentives and weak regulations that hinder industry — **Investor appetite:** Investments in Indonesia focus on technology in general rather than climate technology specifically — **Access to capital:** Weak appetite for investment has left innovators with low access to capital — **Talent:** Limited access to talent to develop, roll out and monitor mobile-enabled technology solutions
Behavioural barriers	**The individual and collective assumptions, beliefs, values and worldviews on climate change responses** — **Unclear value propositions:** Inability to demonstrate the value proposition to end users, coupled with cultural barriers — **Digital literacy:** A barrier for end users that lead to suboptimal use or the need to embed manual back-up methods when rolling out solutions

To address these barriers, the GSMA recommends an ecosystem approach in which mobile-enabled solutions would provide a clear path to achieve Indonesia's climate goals. This would include:

1. **Investing in mobile-enabled connectivity and digital and climate literacy** to reach the most rural areas and offer innovative climate technologies.
2. **Building trust** between stakeholders operating in the same ecosystem, **creating forums to share lessons**, building on successful innovations and developing science-based narratives to strengthen coordination.
3. **Building the capacity of the public sector and communities** to implement or use mobile-enabled climate technology to increase uptake.
4. Using a **human-centred design (HCD) approach to ensure climate technology** is relevant and the value proposition is clear to end users.

2 Introduction

This report explores the potential for mobile-enabled technology solutions to enhance climate mitigation and adaptation efforts in Indonesia.

The report also presents an overview of the main climate challenges facing Indonesia and examines the potential role of mobile-enabled technology in unlocking novel and innovative responses to climate change. The analysis draws on desk research and more than 25 interviews with key stakeholders, including government agencies, mobile network operators (MNOs) and digital technology start-ups.

Overview of the landscape review

Recently, in partnership with Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), GSMA Mobile for Development (M4D) established the Mobile Innovation Hub (MIH) as part of the GIZ Digital Transformation Center (DTC) Indonesia. The MIH will leverage mobile-enabled technology solutions for climate mitigation, resilience and adaptation in Indonesia. In addition to the Indonesian Government, the MIH will work with local stakeholders in areas at the intersection of mobile, digital innovation, sustainable development and climate action.

Our research centred primarily on three areas of climate action in Indonesia: energy, waste and natural resource management. These focus areas were identified based on the Indonesian Government's commitment to climate mitigation and adaptation in each area.[1] It is expected that these focus areas will play a guiding role in the work of the MIH.

Climate mitigation

Climate mitigation involves efforts to reduce the flow of greenhouse gases (GHGs) into the atmosphere, either by reducing the sources of these gases (e.g. the burning of fossil fuels for electricity, heat or transport) or enhancing the "sinks" that accumulate and store these gases (e.g. oceans, forests and soil).[2] In the context of the Paris Agreement, this involves holding the increase in the global average temperature to well below 2° Celsius above pre-industrial levels and pursue efforts to limit it to 1.5°C to significantly reduce the risks and impacts of climate change.[3]

Climate adaptation

Climate adaptation involves adjusting to the actual or expected future climate. The goal of climate adaptation is to reduce vulnerability to the harmful effects of climate change, such as sea-level encroachment, more intense extreme weather events or food insecurity.[4] In the context of the Paris Agreement, this refers to the ability to adapt to the adverse effects of climate change and foster climate resilience and low-GHG development.[5]

1 Republic of Indonesia. (2021). *Indonesia: Long-Term Strategy for Low Carbon and Climate Resilience 2050*.
2 NASA. (2022). *Climate Change Adaptation And Mitigation*. Climate Change: Vital Signs Of The Planet.
3 Climate Transparency. (2021). *Indonesia: Climate Transparency Report: Comparing G20 Climate Action Towards Net Zero*. 1–18.
4 NASA. (2022). Climate Change Adaptation And Mitigation. Climate Change: Vital Signs Of The Planet.
5 Climate Transparency. (2021). Indonesia: Climate Transparency Report: Comparing G20 Climate Action Towards Net Zero. 1–18.

Research objectives

This study focused on five objectives seen as crucial for Indonesia to unlock the power of digital technology and achieve sustainable, low-carbon and climate-resilient outcomes (relevant for SDGs 7, 8, 9, 10, 11, 13, 15 and 17). These are also the areas in which the MIH could focus their support. The objectives are to:

1. Summarise Indonesia's key climate challenges and relevant government targets and programmes. The report explores physical and climatic conditions and how they interact with the country's socio-economic conditions.
   Chapter 3 ▸
2. Map critical stakeholders and explore the role of MNOs, start-ups, SMEs and other local innovators in addressing the identified climate challenges.
   Chapter 4 ▸
3. Identify digital trends, existing innovations and examples of best practices in, or applicable to, Indonesia. The report examines the potential for mobile-enabled technologies to unlock novel and innovative solutions that could respond to the central climate challenges facing Indonesia. The report also explores the most relevant digital use cases and technologies in the three focus areas identified for additional investment.
   Chapter 4 ▸
4. Highlight the specific incentives, bottlenecks, preferences and benefits that stakeholders encounter using digital technology.
   Chapter 5 ▸
5. Identify specific considerations for the GSMA and GIZ to engage directly with stakeholders, foster digital and mobile innovation and expand the reach, scope and effectiveness of the MIH.
   Chapter 6 ▸

Research methodology

The key insights of this landscape review and analysis are based on desk research and stakeholder interviews.

A bespoke framework was developed to organise the findings from a semi-structured literature review of diverse digital technologies and how solutions were being applied in the energy, waste and natural resource management sectors. The findings illustrate trends and gaps in adoption to describe the current landscape of mobile-enabled technologies across the three sectors (see **Chapter 4** ▸).

The findings of the literature review were validated through interviews with stakeholders from the public and private sectors. The sample consisted of more than 25 stakeholders representing MNOs, mobile infrastructure organisations operating in Indonesia and government officials, including seven agencies and ministries. Interviews were also conducted with tech entrepreneurs representing start-ups and incubators, as well as non-governmental organisations (NGOs) working in the three focus sectors with local communities and public and private sector organisations.

A complete list of the organisations engaged through the project can be found in **Appendix D** ▸.

Insights from the literature review and stakeholder engagement were used to develop a macro-level theory of change (see **Chapter 5** ▸) that sets out high-level use cases for mobile-enabled digital technologies, high-level material outcomes that align with each stakeholder group and how they translate into longer term impacts. The theory of change also presents barriers and enablers that will need to be considered in plans to scale and accelerate the impact of mobile-enabled digital technologies to address the climate emergency in Indonesia.

3 Climate change in Indonesia

3.1 Indonesia's climate change challenge

An archipelago nation home to more than 270 million people, Indonesia is particularly vulnerable to the adverse impacts of climate change due to a confluence of geographic, climatic and economic forces.[6] The country's more than 17,500 islands cover 81,000 kilometres of coastline, with ecosystems ranging from sea and coastal environments to peat swamps and dense tropical forests.[7] Indonesia's population is spread over five main islands, with the largest, Java, home to more than 50 per cent of the population and a population density of more than 1,000 people per square kilometre (km²).[8,9]

Indonesia is the largest economy in Southeast Asia and one of the largest global suppliers of palm oil, thermal coal, nickel and gold.[10] The country's economy differs from its neighbours as it is driven largely by domestic activity rather than exports.[11]

The key climate challenges facing Indonesia include extreme flooding, extended droughts, changes in rainfall patterns and temperature and sea-level rise.[12] These risks are compounded by a dense population living in hazard-prone areas. Approximately 60 per cent of all Indonesians live in coastal areas and low-lying coastal cities.[13]

Biodiversity challenges, such as coastal erosion, deforestation and species endangerment, are having direct impacts on vital ecosystems, as well as downstream impacts on agriculture, fisheries and forestry, threatening livelihoods and food security.[14] Indonesia has one of the most biodiverse coral reefs in the world, with more than 590 species of coral identified. Rising water temperature threatens these species and creates human costs associated with reduced amenities and tourism.[15,16] The intersection of human pressures on these biodiverse ecosystems and changes in climate are increasing the risk of ecosystem collapse. This has serious implications for the Indonesian economy, which is dependent on ecosystem services.

Indonesia's climate risks are amplified by carbon-intensive economic activities, such as large-scale deforestation and land conversion for agriculture. Between 2000 and 2017, emissions from land use and land use changes represented 52.3 per cent of the country's total GHG emissions.[17] Higher emissions, coupled with land use changes and greater variability and inconsistency in seasonal rains, are affecting agricultural yields and hindering national progress on poverty and food insecurity.[18] Emissions from energy and fuel combustion are also key sources of GHG, with the energy sector accounting for approximately 43 per cent of Indonesia's emissions in 2019.[19]

6 World Bank. (n.d.). "Population Total – Indonesia". Accessed 20 and 21 June 2022.
7 Ibid.
8 BPS – Statistics Indonesia. (2021). *The Indonesian Population Census 2020 Highlights*, 10.
9 Ghosh, I. (23 August 2021). "What are the world's biggest islands? Here's a visualization of the top 100". *World Economic Forum*.
10 OECD. (2022). *OECD Economic Outlook*, Volume 2022, Issue 1: Preliminary version.
11 Asialink Business. (n.d.). "Indonesia's Economy". Accessed 21 June 2022.
12 World Bank Group and Asian Development Bank. (2021). *Climate Risk Country Profile, Indonesia*, p. 3.
13 United Nations. (n.d.). *Climate Change and its Possible Security Implications Indonesia*, p. 2.
14 Ibid.
15 Asian Development Bank. (2014). *State of the Coral Triangle: Indonesia*.
16 United Nations. (n.d.). *Climate Change and its Possible Security Implications Indonesia*, p. 2.
17 Kementerian PPN/ Bappenas, ICCTF. (2019). *Low Carbon Development: A Paradigm Shift Towards a Green Economy in Indonesia – Full Report*, 35.
18 United Nations. (n.d.). *Climate Change and its Possible Security Implications Indonesia*, p. 2.
19 Statista. (2019). "Share of greenhouse gas (GHG) emissions from energy sector in Indonesia in 2019, by source". Accessed 20 June 2022.

3.2 Indonesia's climate change response

In response to these climate change threats, the Indonesian Government has made a series of commitments to reduce GHG emissions and manage climate risks. Indonesia's first national strategy on climate change was released by the Ministry of Environment in 2007.[20] In 2016, Indonesia submitted a 2030 climate pledge, or National Determined Contribution (NDC), within the framework of the Paris Agreement to achieve 29 per cent of the reference emissions level by 2030 with an unconditional target, and up to 41 per cent with international support (conditional target).[21] In 2021, as part of Indonesia's Long-Term Strategy for Low Carbon and Climate Resilience 2050 (LTS-LCCR 2050), the government set an even more ambitious goal to achieve peak national emissions in 2030, reaching 540 mega-tonnes of carbon dioxide equivalent GHG emissions ($MtCO_2$-e) by 2050, and exploring a pathway to net-zero emissions by 2060 or sooner.[22]

To support these efforts, the government has developed a range of legal and policy instruments. The main policy addressing environmental issues in Indonesia is Law No. 32/2009 on Environmental Protection and Management.[23] Ministerial Regulation (Ministry of Environment and Forestry) No. 33/2016 provides guidance for national and local governments to plan climate change adaptation actions and integrate them in the development plans of specific regions and/or sectors.[24]

Ministerial Regulation (Ministry of Environment and Forestry) No. 7/2018 provides guidance for national and local government (and the broader society) on:

- Determining the scope of the analysis, selection of methods, indicators, indicator data and data sources for formulating vulnerability, risk and impact assessments of climate change; and
- Determining the criteria for verification of vulnerability, risk and climate change impact assessment results.[25]

Figure 1 depicts the policy and regulatory frameworks supporting climate change mitigation and adaptation in Indonesia.

In addition to policy and legal infrastructure, Indonesia has introduced a range of climate mitigation and adaptation measures to help reduce emissions and manage climate risks. The government has prioritised mitigation and adaptation efforts in three sectors: (1) energy; (2) waste; and (3) agriculture, forestry and land use, which includes land use changes, and will be referred to as "natural resource management" throughout this report.[26]

These sectors represent a significant proportion of the country's carbon emissions and are highly exposed to physical climate risks, as shown in Figure 2. Each sector is explored in the following section, including key mitigation and adaptation interventions.[27]

20 World Bank Group and Asian Development Bank. (2021). *Climate Risk Country Profile, Indonesia*, pp. 4–5.
21 Ibid.
22 Republic of Indonesia. (2021). *Indonesia: Long-Term Strategy for Low Carbon and Climate Resilience 2050*, p. 33.
23 Ibid., p. 23.
24 Ibid.
25 Ibid.
26 Ibid., p. 3.
27 Climate Transparency. (2021). *Indonesia: Climate Transparency Report: Comparing G20 Climate Action Towards Net Zero*, pp. 1–18.

Figure 1

National policy and regulatory framework supporting climate change mitigation and adaptation[28]

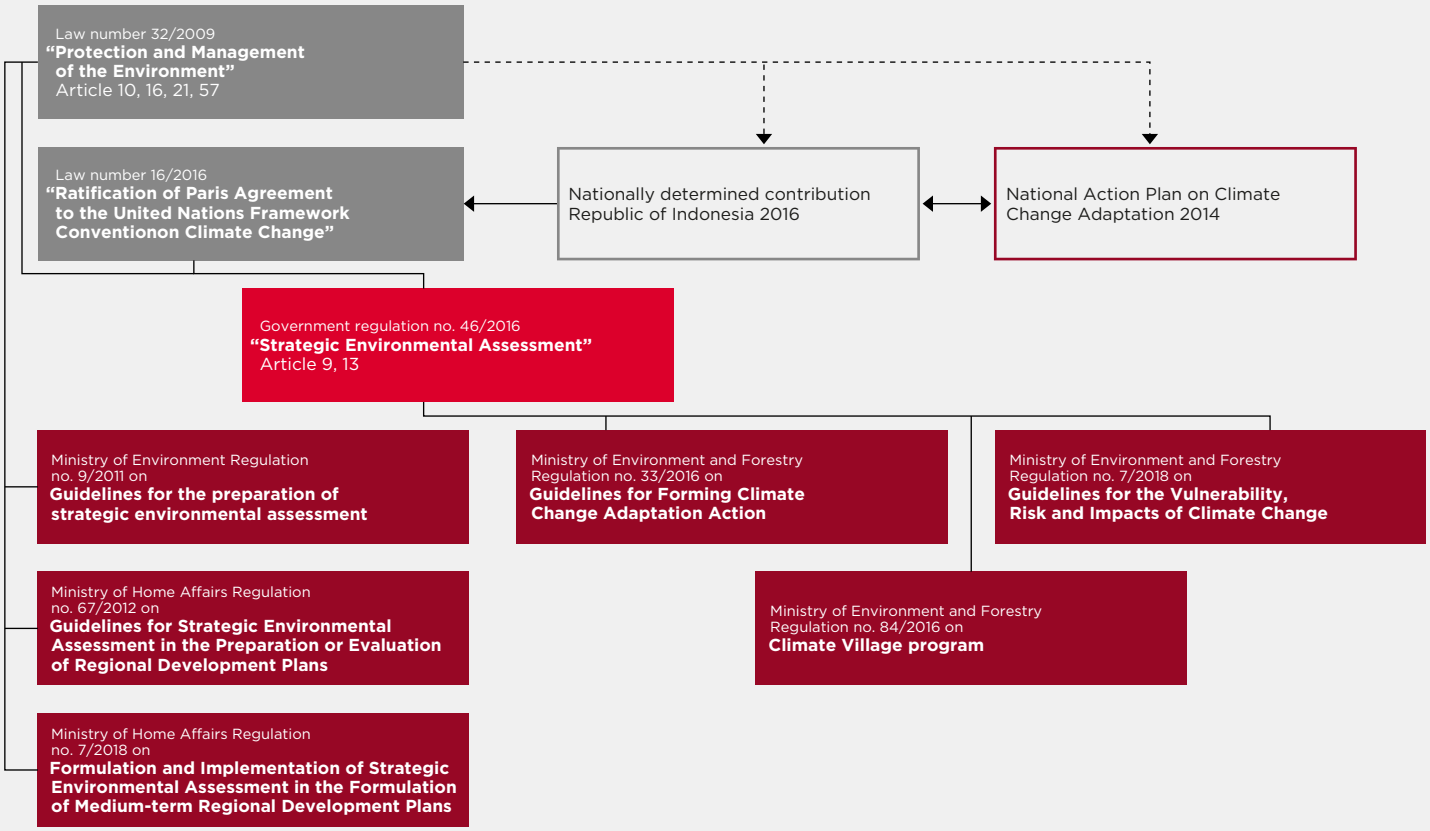
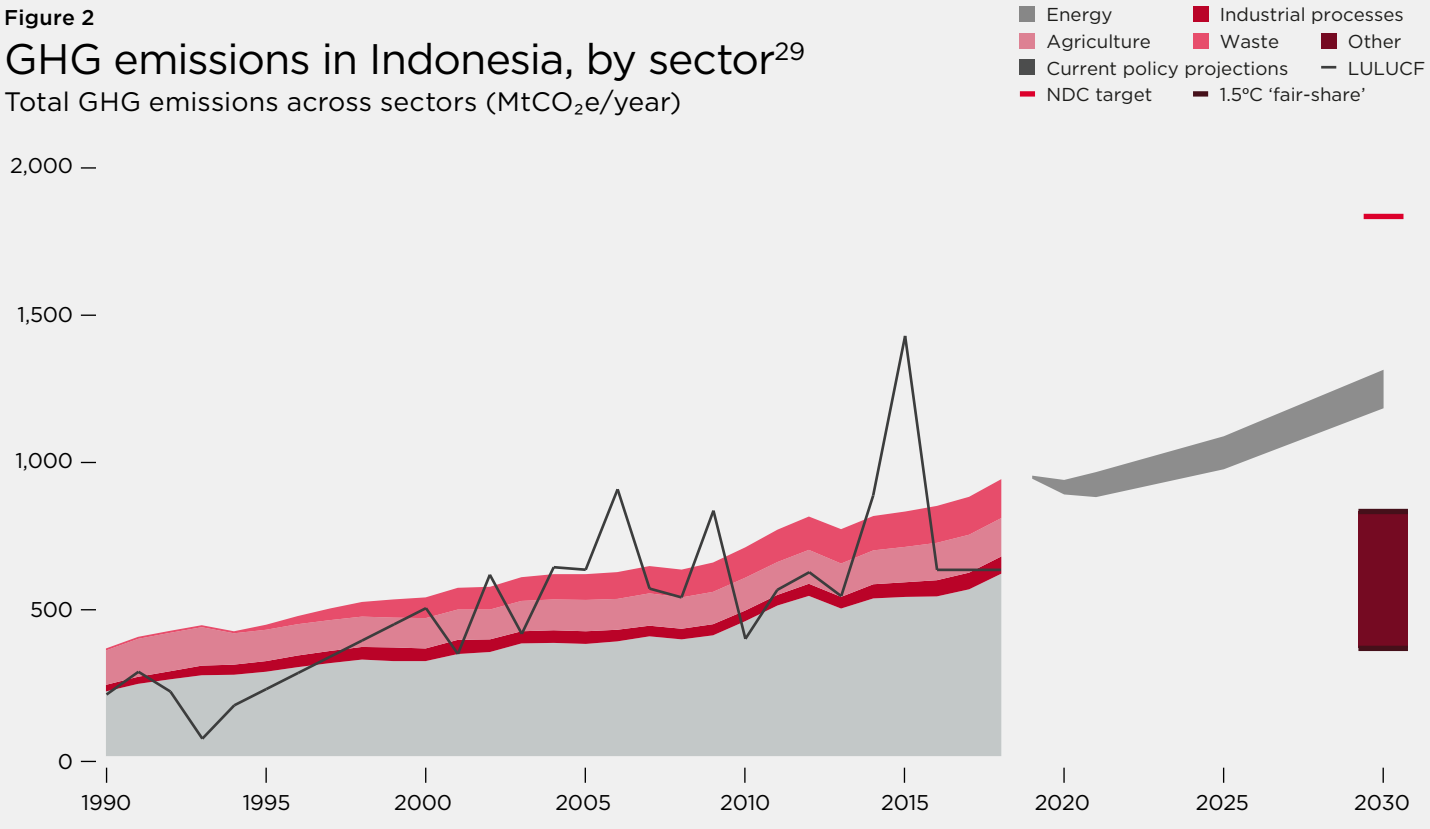


Figure 2

GHG emissions in Indonesia, by sector[29]

Total GHG emissions across sectors ($MtCO_2e$/year)



28 Republic of Indonesia (2021), *Indonesia Long-Term Strategy for Low Carbon and Climate Resilience 2050* (Indonesia LTS-LCCR 2050) (unfccc.int).

29 Climate Transparency (2021), *Indonesia: Climate Transparency Report: Comparing G20 Climate Action Towards Net Zero*, 1–18

3.3 Energy

Indonesia consumes a significant amount of energy. Average annual use per capita is 34.4 gigajoules (GJ) and rising at a rate of 7.52 per cent a year, compared to the average growth rate of 0.12 per cent in G20 countries between 2015 and 2020.[30] This growing demand for electricity is in a context of rapid economic development, population growth and changing climatic conditions. This is compounding pressure on the energy sector, which has seen a 277 per cent increase in power consumption per capita from 2000 to 2019.[31] The rapid increase in demand is also due to increased electrification, as segments of the population that have historically had limited or no access to power are gradually being connected to energy sources.[32]

Also related to this growth is the relative carbon intensity of Indonesia's energy generation, 75 per cent of which is through the burning of fossil fuels, including oil, coal and gas.[33] Between 2015 and 2020, carbon intensity in Indonesia increased by 13.6 per cent, reaching more than 60 tCO_2-e/TJ in 2020, while overall carbon intensity in G20 countries has dropped.[34]

In response to a growing energy sector and rising emissions, the government has introduced policy and regulatory interventions to reduce reliance on carbon-intensive energy generation through fossil fuels, and to support the growth of the renewable energy sector. These policies also target adaptation measures related to land rehabilitation that can enhance biodiversity as well as reduce emissions. These policies and priority actions focus on rapid uptake of renewable energy, increasing energy efficiency and reducing reliance on coal-fired power plants.

While these interventions demonstrate a clear willingness and concrete actions to curb Indonesia's GHG emissions, protect ecosystems and propel the transition to renewable energy, Indonesia continues to face challenges in decarbonising the energy sector. This is due to continued support of emissions-intensive energy solutions in the immediate term, which is hampering the ability of the country to rapidly transition and achieve long-term emissions reduction objectives.

One of the main challenges is continued investment in coal-fired assets into 2023 and subsidies for coal-generated power.[35] In the immediate term, this creates a barrier for renewable energy companies to raise investment capital as they compete with an abundance of subsidised fossil fuel sources.

This challenge is compounded by rapidly growing demand for energy, both in metropolitan and remote regions of the country. Alternative fuel sources, such as biofuel, are beginning to be used to meet demand and have potential to reduce emissions. However, one of the main components of biofuels is drawn from palm oil, raising concerns about impacts on biodiversity and sustainable development.[36]

Despite prioritising the decarbonisation of the energy sector, these challenges signal broader systemic obstacles for Indonesia to achieve its decarbonisation objectives while also managing economic and population growth.

30 Climate Transparency. (2021). *Indonesia: Climate Transparency Report: Comparing G20 Climate Action Towards Net Zero*, pp. 1–18.
31 World Bank. (n.d.). "Electric power consumption (kWh per capita) – Indonesia". Accessed 21 June 2022.
32 World Bank. (n.d.). "Access to electricity (% of population) – Indonesia". Accessed 21 June 2022.
33 Climate Transparency. (2021). *Indonesia: Climate Transparency Report: Comparing G20 Climate Action Towards Net Zero*, pp. 1–18.
34 Ibid.
35 Knowledge Centre Perubahan Iklim. (n.d.)."Adaptasi" [Adaption]. Accessed 22 June 2022.
36 Republic of Indonesia. (2021). *Indonesia: Long-Term Strategy for Low Carbon and Climate Resilience 2050*, p. 52.

Policies and mechanisms to reduce reliance on carbon intensive energy generation:

A plan to develop a "National Vision for Non-Motorised Transport" document as a practical guide for city governments to plan and prioritise the needs of pedestrians and cyclists. The need for this plan arose from the rapid growth of private cars and motorcycles due to unreliable public transport, low parking prices and subsidised fuel.

A commitment to not build any new coal-fired power plants after 2023 and to phase out all coal-fired power plants by 2060.[37] However, approximately 26 GW of coal plants are at various stages of construction, a signal that Indonesia will sustain its immediate reliance on fossil fuels and continue to address the challenges associated with short-term emissions reduction efforts.[38]

The establishment of an industrial energy efficiency policy, which requires all companies with an annual energy consumption of more than 6,000 tonnes of oil equivalent to appoint an energy manager, develop an energy conservation plan, perform an energy audit and report energy consumption. The National Energy Policy includes an incentive mechanism to encourage good practices in energy conservation in industrial processes.[39]

The National Grand Energy Strategy (GSEN), a strategy for Indonesia to reach net-zero emissions (NZE) by 2060 or sooner, which will be formally announced and implemented at the G20 in November 2022. The strategy will set a national target of 100 per cent renewable energy by 2060.[40]

The Sustainable Energy Fund (SEF), which offers an incentive programme for rooftop solar panels, is a collaboration between the Ministry of Energy and Mineral Resources and the United Nations Development Programme (UNDP). The programme is projected to cut carbon emissions by 4.5 $MtCO_2$-e.[41]

The use of degraded land for renewable energy by rehabilitating these areas with species that can create energy from biofuels, and research and development to support sustainable biomass energy plantations and bioenergy industries.[42]

The promotion of energy independence by improving and conserving rain catchment areas and watersheds that are sources of hydropower and geothermal energy. This also includes optimising the use of organic waste and biomass and developing biofuel energy sources.[43]

37 Climate Transparency. (2021). *Indonesia: Climate Transparency Report: Comparing G20 Climate Action Towards Net Zero*, pp. 1–18.
38 Ibid.
39 Climate Transparency. (2021). *Indonesia: Climate Transparency Report: Comparing G20 Climate Action Towards Net Zero*, pp. 1–18.
40 Ministry of Energy and Mineral Resources, Republic of Indonesia. (4 February 2022). "Indonesia to introduce Grand Energy Strategy during G20 2022".
41 Ministry of Energy and Mineral Resources, Republic of Indonesia. (10 February 2022). "Energy Ministry Launches SEF Grant for Rooftop Solar Systems".
42 Ibid.
43 Knowledge Centre Perubahan Iklim. (n.d.)."Adaptasi" [Adaption]. Accessed 22 June 2022.

3.4 Waste

Mismanaged plastic waste poses a significant threat to marine and land biodiversity in Indonesia and is a major contributor to GHG emissions. Indonesia generates approximately 38 million tonnes of municipal waste and 7.1 million tonnes of plastic waste annually, with 4.4 million tonnes of plastic waste mismanaged each year.[44] Despite having an almost equal population as urban areas, rural areas generate approximately two-thirds of mismanaged plastic waste, with 85 per cent of plastic waste regularly uncollected due to limited waste collection infrastructure.[45] While rural areas bear the greatest burden of mismanaged plastic waste, 40 per cent of Indonesia's 142 million urban residents do not have access to basic waste collection services.[46]

Landfill sites in Indonesia are typically located near public areas. As a result, when toxic wastewater seeps into nearby landholdings, it affects the quality of potable and irrigation water. Most landfills in Indonesia lack sufficient leachate treatment facilities to manage harmful impacts on local water sources. Leachate containing suspended and dissolved solid pollutants and chemicals such as ammonia, nitrates and heavy metals, leach into water bodies, posing public health risks.[47] Additionally, more than 70 per cent of reduce, reuse and recycle waste management facilities (TPS3R) and 40 per cent of integrated waste management facilities (TPST) in Indonesia are abandoned or of unknown status. This has resulted in some landfill zones becoming open dumping areas, intensifying the impacts of leachate in local water sources.[48]

Open burning of mismanaged waste, including plastic waste, is also common in Indonesia. More than 9.4 million tonnes of GHG were emitted in 2017 from the burning of mismanaged waste.[49] The burning of plastic waste also emits large amounts of toxic gases that are harmful to humans, vegetation and animals, and can cause a wide variety of serious health issues in humans, including aggravated respiratory illnesses.[50,51]

Waste is a major challenge to the livelihoods of Indonesians and the marine and land environments on which they depend. While the government is seeking to play a more active role, the country faces a variety of challenges with waste management and data and information sharing on waste and plastic management is limited, hindering the government's ability to understand the scale of the issue.[52]

The historical lack of waste infrastructure in Indonesia has contributed to negative public attitudes about waste management,[53] creating a need for behaviour change communication and better information and education on how to manage household waste.

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44 World Bank. (2021). *Plastic Waste Discharges from Rivers and Coastlines in Indonesia. Marine Plastics Series, East Asia and Pacific Region*, p. 14.

45 World Bank. (2021). *Plastic Waste Discharges from Rivers and Coastlines in Indonesia*, p. 14.

46 Ibid.

47 Emalya, N. et al. (2020). "Landfill Leachate Management in Indonesia: A Review" (Paper presented at IOP Conference Series: Materials Science and Engineering, 845 012032), pp. 4–6.

48 SYSTEMIQ. (June 2021). "Indonesian Government aims for 80% waste management target by 2025".

49 World Economic Forum. (April 2020). *Radically Reducing Plastic Pollution in Indonesia: A Multistakeholder Action Plan National Plastic Action Partnership*, p. 12.

50 Zhu, Y. et al. (2020). "Association between short-term exposure to air pollution and COVID-19 infection: Evidence from China". *Science of the Total Environment*, p. 727.

51 Verma, R. et al. (2016). "Toxic Pollutants from Plastic Waste: A Review". *Procedia Environmental Sciences*, 35, pp. 701–708.

52 Ibid.

53 Ibid.

The Indonesian Government and waste management industry have acknowledged the need to establish a long-term roadmap to manage waste based on reuse, reduction, avoidance and, where required, destruction.[54] Current government initiatives and responses include:

Indonesian President Regulation No. 97/2017, a roadmap to the 2025 Clean-from-Waste Indonesia (JAKSTRANAS) that aims for a 30 per cent reduction in waste and a 70 per cent reduction in waste handling by 2025.[55]

The **Ministry of Environment's waste banks** are intended to improve urban waste management infrastructure. Waste banks are community-based assets for collecting sorted inorganic waste with economic value. Customers bring non-organic waste to a bank where the waste is treated as a deposit and then sold to mobile agents for reuse or recycling.[56]

The **Ministry of Environment's Program Kampung Iklim (ProKlim), or Climate Village Program**, aims to increase the involvement of communities and other stakeholders to strengthen their adaptation capacity to respond to climate change impacts and reduce GHG emissions. One of the main components is raising awareness of waste management in communities to avoid flooding and landslides.[57]

The 2020 National Plastic Action Partnership, which covers priority actions across the waste ecosystem to meet the goal of near-zero plastic pollution by 2040. Under the Action Partnership's System Change Scenario (SCS), Indonesia will:[58]

- Double plastic waste collection to more than 80 per cent by 2025;
- Double current recycling capacity by 2025; and
- Build or expand controlled waste disposal facilities to safely manage non-recyclable plastic waste.

Under the SCS, Indonesia is expected to prevent 16 million tonnes of plastic from entering its coastal waters, curb 20 million tonnes of GHG emissions per year, create more than 150,000 jobs and significantly improve public health outcomes. The plan will also seek to influence behaviour change, strengthen policies and regulation and invest directly in programmes that promote better waste management or waste reduction.

54 Republic of Indonesia. (2021). *Indonesia: Long-Term Strategy for Low Carbon and Climate Resilience 2050*, pp. 1–3.
55 Ministry of Environment and Forestry, Republic of Indonesia. (2020). *National Plastic Waste Reduction Strategic Actions for Indonesia*, pp. 1–33.
56 Ministry of Environment and Forestry, Republic of Indonesia. (2020). *National Plastic Waste Reduction Strategic Actions for Indonesia*, pp. 1–33.
57 Dinas Lingkungan Hidup. (1 October 2019). "Program Kampung Iklim (Proklim)" [Climate Village Program (Proklim)].
58 World Economic Forum. (April 2020). *Radically Reducing Plastic Pollution in Indonesia: A Multistakeholder Action Plan National Plastic Action Partnership*, p. 19.

3.5 Natural resource management

Indonesia's forest and marine ecosystems are home to a significant number of species. While the nation has the second highest rate of biodiversity in the world,[59] it also has the most endangered species in Southeast and South Asia.[60] Habitat degradation and fragmentation are suspected as the main causes of extinction of various species of biodiversity.[61]

Habitat degradation and fragmentation also have broader climate impacts, with emissions from land use, land use changes and forestry (LULUCF) contributing significantly to Indonesia's GHG emissions. The conversion of peatlands and forested regions into agricultural plantations have led to the erosion of natural carbon sinks, which, coupled with major fires in peatlands, have driven up emissions. Every year since 2012, 550 to 1,200 $MtCO_2$-e has been emitted due to LULUCF.[62] Indonesia's peatland fires can produce toxic haze, with severe impacts on public health and the economy, both within Indonesia and in neighbouring countries.[63] Agricultural productivity is also anticipated to suffer as greater seasonal variability affects crop yields and, ultimately, food security.[64]

Indonesia also has the world's richest coastal blue carbon ecosystems, including around 3 million hectares (Mha) of mangroves that store 3.14 billion tCO_2-e of carbon and 0.3 Mha of seagrass meadows that store 0.39 billion tCO_2-e.[65,66] These habitats are under significant threat. In the three decades prior to 2015, Indonesia lost 40 per cent of its mangroves due to rapid economic and population growth and an increase in both illegal and legal fishing activities.[67]

The conversion of peatlands and forested regions into agricultural plantations have led to the erosion of natural carbon sinks, which, coupled with major fires in peatlands, have driven up emissions.

59 Maskun et al. (2021). "Threats to the sustainability of biodiversity in Indonesia by the utilization of forest areas for national strategic projects: A normative review" (Paper presented at 2nd Biennial Conference of Tropical Biodiversity), IOP Conference Series: Earth and Environmental Science, 886 012071.

60 Ibid.

61 Ibid., p. 6.

62 Climate Analytics, Next Climate Institute and Climate Action Tracker. (October 2021). *Climate Governance: Assessment of the government's ability and readiness to transform Indonesia into a zero emissions society*, pp. 2–19.

63 Caermta, R., Zabala, A. and Phelps, J. (November 2015). *Indonesian Peatland Fires: Perceptions of Solutions*, pp. 2–4. CIFOR and CGIAR.

64 Republic of Indonesia. (2021). *Indonesia: Long-Term Strategy for Low Carbon and Climate Resilience 2050*, p. 18.

65 Daniel Murdiyarso et al. (November 2018). "Creating blue carbon opportunities in the maritime archipelago Indonesia". Policy Brief No. 3, pp. 1–4.

66 Ibid.

67 Ibid.

In response to the significant climate threat posed by LULUCF and marine ecosystem degradation, the Indonesian Government has introduced a range of policies and approaches to reduce the impacts on biodiversity and GHGs. These include:

- Indonesia's Low Carbon Development and National Long-Term Development Plan (RPJPN) policies, which support efforts to reduce emissions from deforestation and forest degradation and to manage land use planning.[68] However, in 2020, the national government enforced the Job Creation Law, which has created potential loopholes for an increase in deforestation.[69]
- A government-led programme that seeks to provide communities with legal access to 12.7 Mha of state forests, allowing them to manage these resources sustainably for their own livelihoods and protect forests and biodiversity.[70]
- The Environment Fund Management Agency (BPDLH), which is tasked with managing environmental funds, including a results-based payment mechanism to reduce emissions from deforestation and forest degradation (REDD+) and preside over agricultural productivity.[71]
- Efforts to restore 2.4 Mha of degraded peatlands, which are mandated by Presidential Regulation Number 1 of 2016 and a moratorium policy that bans the clearing of primary forests and peatlands. This has led to a 45 per cent drop in deforestation inside moratorium areas in 2018 compared to 2002–2016.[72]
- A government target to rehabilitate 600,000 ha of mangroves by 2024. The government has also included mangrove restoration as part of the National Recovery Program. The Coordinating Ministry for Maritime Affairs and Investment (CMMAI) is mandated to coordinate the related ministries and agencies, including the Ministry of Marine Affairs and Fisheries, Ministry of Environment and Forestry and the Peatland and Mangrove Restoration Agency (BRGM), to support mangrove rehabilitation across provinces in Indonesia.[73]
- The BRGM is a national agency tasked with preventing land fires, including some peatland areas, and restoring more than 2.6 Mha of forest and peatlands devastated by the 2015 fires. The BRGM has called on the United Nations Environment Programme (UNEP) and partners to establish the Global Peatlands Initiative – a partnership that would convene to save peatlands as the world's largest terrestrial organic carbon stock.[74]
- Paris Agreement-aligned policies and measures (PaMs) to maximise the use of unproductive lands (idle lands) for the establishment of forestry and agricultural plantations. This is supported by other PaMs designed to enhance agricultural value chains, increase and improve market access for smallholder farmers, reduce food loss and waste, improve diets and enhance food diversification and access.[75]

68 World Bank. (11 January 2021). "Indonesia Takes a Landscape Approach to Reduce Deforestation, Address Climate Change".

69 Climate Analytics, Next Climate Institute and Climate Action Tracker. (October 2021). *Climate Governance: Assessment of the government's ability and readiness to transform Indonesia into a zero emissions society*, pp. 2–19.

70 World Bank. (21 October 2021). "Opening the Door to Community Forest Access and Management in Indonesia".

71 World Bank. (11 January 2021). "Indonesia Takes a Landscape Approach to Reduce Deforestation, Address Climate Change".

72 Arief Wijaya et al. (24 July 2019). "Indonesia Is Reducing Deforestation, but Problem Areas Remain". World Resources Institute.

73 World Economic Forum. (18 September 2021). "How Indonesia is protecting its 'climate guardians'".

74 UNEP. (4 June 2019). "Working as one: how Indonesia came together for its peatlands and forests".

75 Republic of Indonesia. (2021). *Indonesia: Long-Term Strategy for Low Carbon and Climate Resilience 2050*, p. 37.

These policies and interventions signal that the government recognises the importance of preserving and restoring forested and coastal environments for climate mitigation and biodiversity preservation, and of maximising the potential of agriculture sustainably.

However, there are persistent challenges in achieving positive natural resource management outcomes. Unsuccessful restoration of peatlands in privately owned concession areas is widespread in Indonesia, with many companies failing to comply with regulations. A primary reason for this low level of compliance is that the BRGM has no legal authority to work in private plantations and forest areas, which represent 1.7 Mha of the total 2.6 Mha of degraded peatland inside forest areas and palm oil concessions.[76] Compounding this is fragmented and overlapping legal authority and responsibility for peatlands, which have created tension between the BRGM and the Ministry of Environment and Forestry. It has been reported that, at times, the Ministry has been hesitant to share information with the BRGM on the progress of peatland restoration projects inside forestry concessions.[77]

The BRGM has also struggled to develop a comprehensive plan for peatland restoration due to a lack of image data from the fields. The Ministry of Environment and Forestry was tasked with producing this data on maps, but issued them at a resolution too low (1:250,000) for operational use[78].

Meanwhile, mangrove degradation and deforestation continue to be widespread, with low legal and regulatory compliance, poor law enforcement and discordant policies.[79]

Although several policy initiatives offer social and economic incentives for community participation in mangrove management, these efforts have encountered problems related to uncertain land tenure, land encroachment, elite capture of land and unfair benefit sharing. The involvement of local communities in natural resource management has run up against other challenges as well, including differing goals and limited capacity and time to develop and maintain sustainable natural resource management.[80]

76 Astuti, R., Taylor, D. and Miller, M.A. (18 December 2020). "Indonesia's Peatland Restoration Agency gets an extension despite failing to hit its target: what are the hurdles and next strategies?". *The Conversation*.

77 Ibid.

78 Ibid.

79 Budi Arifanti, V. et al. (2022). "Challenges and Strategies for Sustainable Mangrove Management in Indonesia: A Review". *Forests*, 13, p. 695..

80 Ibid.

4 The state of mobile-enabled climate technology in Indonesia

Climate technology solutions in Indonesia are on the rise, most notably in renewable energy, energy efficiency, smart agriculture, integrated waste management and the circular economy.

This growth is being matched by public and private investment that is seizing on the significant opportunity to unlock positive climate mitigation and adaptation outcomes.

Indonesia is also experiencing rapid uptake of mobile technology as it becomes more accessible and affordable and connectivity improves. The expansion of climate technology solutions and rapid adoption of mobile technology provide a strong foundation for mobile-enabled climate technology solutions in Indonesia. However, the country still faces barriers to harnessing these solutions in meaningful ways. These barriers, along with the key opportunities, are explored in this section.

4.1 Current use of climate technology

Indonesia's start-up sector and digital economy are growing rapidly, and the country is predicted to surpass Singapore as the region's largest digital economy by 2025. This technological advancement is attracting environmental, social and governance (ESG)-conscious innovators backed up by a new wave of angel investors who are driven primarily by the chance to have a positive environmental and social impact.

To help illustrate the distribution of climate technology in Indonesia, including where investment is primarily focused, the GSMA ClimateTech programme reviewed publicly available literature and compiled an illustrative list of 48 examples of climate technology solutions that have been deployed, piloted or are in the proof-of-concept stage. A Boolean search was conducted using search terms in both English and Bahasa Indonesia.

A mobile-enabled climate technology framework, which appears in Appendix A, was developed to categorise these technologies and highlight trends in climate technology innovations. Climate technology solutions were classified into 16 technology types (see Table 2). Finally, technologies were mapped to the three focus areas of energy, waste and natural resource management to understand the distribution of these technologies in Indonesia's priority sectors with regard to climate change.

Table 2

Current use of climate technology in Indonesia

Platform level 	Smart M2M technology, sensor technologies, blockchain, AI
Application level 	Call centres, interactive content, peer-to-peer content, push content, data collection tools, inventory management tools, mobile payments
Device level 	Niche devices, handsets, network devices
Network level 	Infrastructure, software

The mobile-enabled climate technology framework reveals that solutions tend to be concentrated in certain technology categories. At the technology level, most solutions occurred at the network level, with relatively even distribution of infrastructure and software solutions. These solutions focused primarily on renewable energy, energy management, sorting and recycling and waste collection and route efficiency. Natural resource management solutions focused more heavily on forestry management and marine ecosystem management at the network level.

A large volume of solutions at the network level suggests that technology solutions in Indonesia tend to focus on foundational infrastructure and technological needs, rather than the application of innovative technologies.

However, blockchain and AI appear to be key emerging climate technology solutions in Indonesia, appearing evenly across the energy, waste and natural resource management sectors. This suggests an appetite for using emerging technology solutions to address the nation's central climate challenges.

Additionally, niche devices such as drones and robots are being piloted in natural resource management settings, indicating a growing interest in this space.

At the sector level, the framework shows that most climate technology solutions are in the energy and waste sectors, with just under half of climate solutions related to waste.

Figure 3

Concentration of solutions at the network level

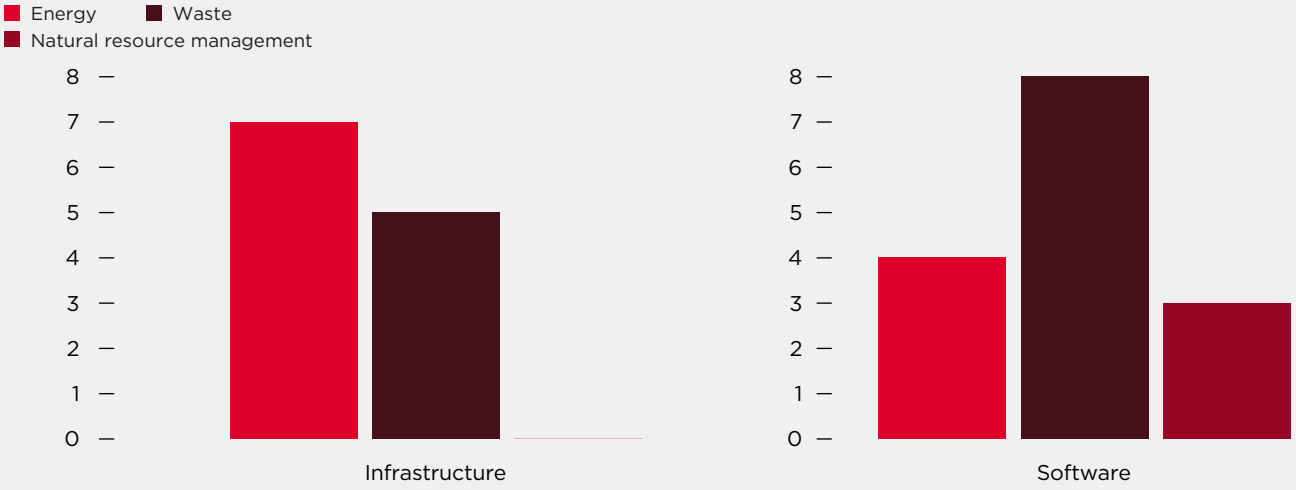


Figure 4

Emerging climate technology solutions

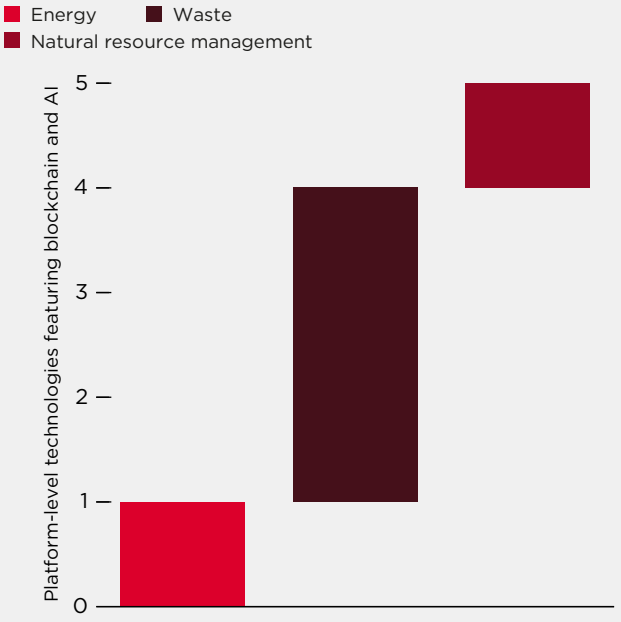
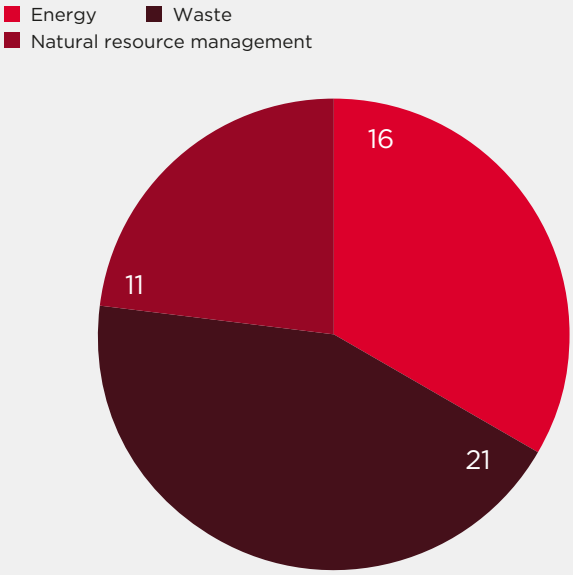


Figure 5

Mobile-enabled climate technology solutions, by sector



Overall, sorting and recycling technologies were one of the most frequently identified solutions. This sector may be buoyed by recent government interventions to curb the nation's plastic waste issues. Energy management was also a common solution, with rapid growth in energy-efficient technologies and Indonesia's GHG reduction commitments acting as key drivers. Within the natural resource management sector, forestry management solutions were commonly identified and focused on the biodiversity protection and management of illegal deforestation to preserve Indonesia's forested environments.

The climate technology framework indicates that the marketplace for climate solutions is maturing in Indonesia. However, these solutions are largely concentrated around foundational technology, such as infrastructure and fundamental software. Despite this, the increased presence of emerging technologies such as blockchain, AI and niche devices, coupled with the expansion of ESG investment in Indonesia, suggest a growing appetite for innovative technology solutions to address climate challenges.

Figure 6

Distribution of climate technology solutions, by sub-sector

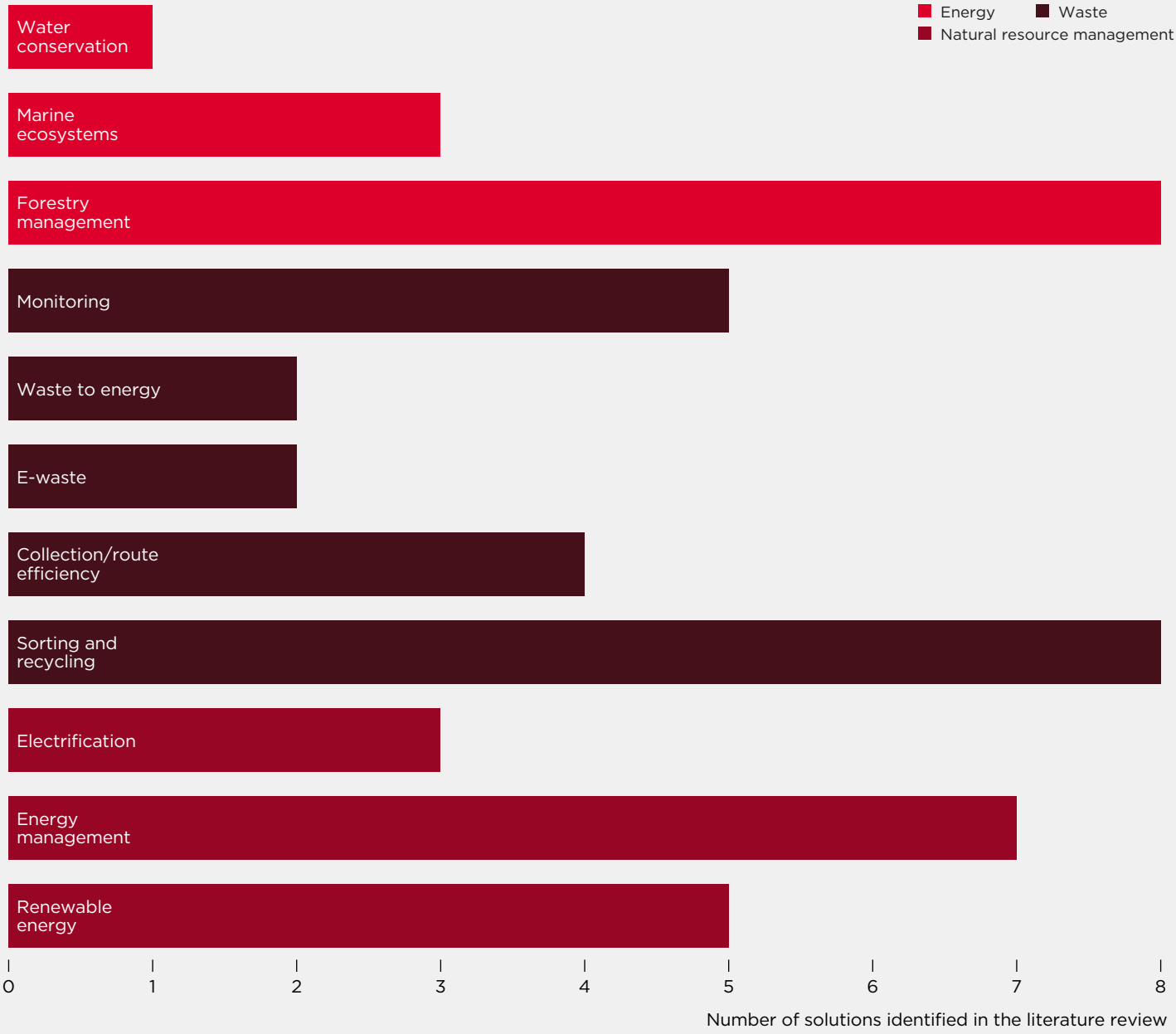


Figure 7

Mobile-enabled climate-tech solutions in Indonesia

Forest

- **1** Drones to identify deforestation GIZ
- **2** (WRI) interactive maps for Indonesian forests – interactive content
- **3** IoT technology to map out forest-fire risks
- **4** (Ruai TV) community based peer-peer content to report on deforestation / abuse
- **5** (Microsoft) carbon emissions & reforestation
- **5** INCAS, data collection (remote sensing and satellite) to measure GHG emissions
- **6** KKI using (AI) tool to detect illegal logging noises
- **7** CT-Smart real time data on poaching in forests
- **8** SMS alert (community for pollution swamp forest)

Waste management

- **9** (Kaktus) Barcode for waste sorting
- **9** (Griya Luhu) Waste segregation with barcode
- **10** Qlue Perfoma to monitor waste generation and flooding using AI and IoT
- **10** Gringgo – AI and blockchain to monitor waste treatment information in Bali
- **10** BuMoon IoT and AI solution to calculate reward for waste
- **10** Rekosistem providing waste management solutions using tech such as AI
- **11** (Surplus) buy excess food from restaurants
- **11** Blitar City, in East Java used mobile handsets and technology to manage waste bank activities
- **11** Octopus software connects households with waste pickers
- **11** Duitin software helps managing the waste management process and tracking of waste for ESG reporting (B2B)
- **12** E-waste RJ, interactive content for awareness creation on e-waste
- **13** Waste4Change, wholistic waste management solutions

Community

- **14** IGE – Crowdsourced, Renewable Energy Donation Platform
- **15** Electric Vine and ENGIE A smart photovoltaic micro-network development
- **16** Xurya helping rooftop owners to install sloar PV
- **16** Solar Hub software help with solar PV for rooftops
- **17** Creating ecosystem for solar vehicles and solar panels.
- **18** Gogoro (Gojek) battery swap for small scooters

Coastal area

- **19** Swandiri institute (Drones) for lake activity monitoring
- **20** Aruna, Indonesian Fisheries e-commerce application.
- **21** E-fishery, precise feeding and cultivation of fish (monitoring software)

4.2 The mobile technology landscape

The mobile sector in Indonesia is experiencing considerable growth and advancing the country's transition to a technologically advanced, knowledge-based society. 3G services are available across most urban centres, smartphone adoption is rising and uptake of 4G and 5G is beginning to increase. Indonesia is also home to an expanding middle class and an educated, tech-savvy young population, both of which are driving a booming e-commerce market.[81]

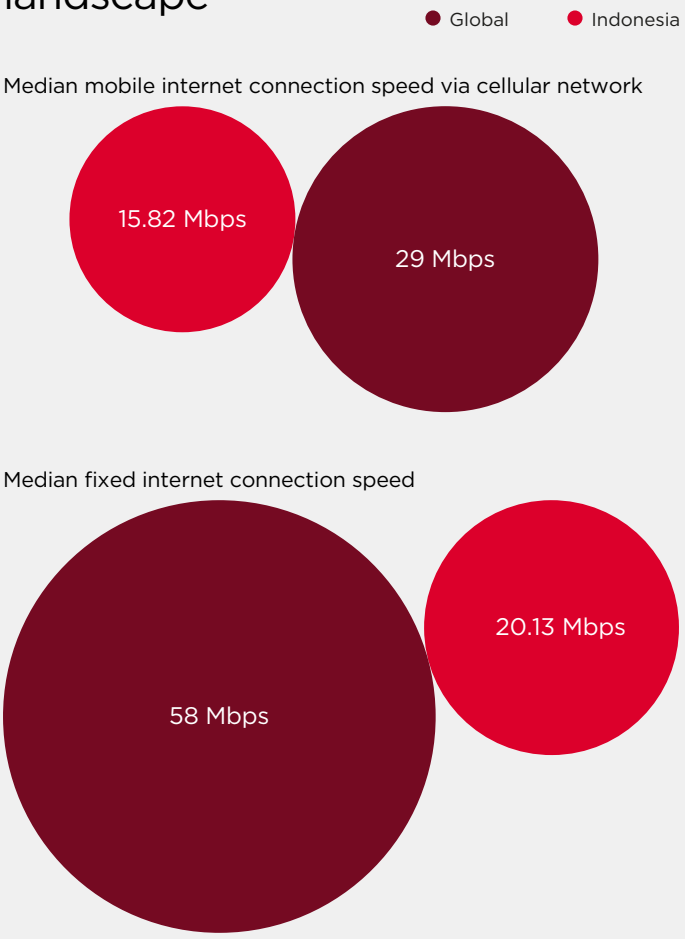
Mobile technology is supporting the digital transformation of traditional industries, including agriculture and manufacturing, and stimulating innovation among domestic start-ups. 4G networks and the emerging ultrafast 5G are fundamental to enabling digital inclusion and delivering the connectivity requirements of citizens and traditional and emerging industries.[82]

At the beginning of 2022, it was estimated there was 73.7 per cent internet penetration in Indonesia.[83] In 2021, approximately 202 million internet users contributed USD 70 billion to the country's digital economy.[84] The Ministry of Finance estimates that technology development could add 0.55 percentage points to GDP growth between 2020 and 2030 – equivalent to $2.8 trillion.[85]

Indonesia has the fourth largest smartphone market in the world, with more than 61 per cent of the population using a smartphone in 2021.[86] Reports by Ookla reveal the median mobile internet connection speed has increased by 3.40 megabits per second (Mbps) or by 27.4 per cent within 12 months to the start of 2021. However, the median mobile and fixed internet connection via cellular network is still well below the global median (Table 3).

Table 3

Indonesia's mobile technology landscape



81 GSMA. (2020). *Spotlight on Indonesia: Seizing the digital transition opportunity now*, pp. 3–8.
82 Ibid.
83 Kemp, S. (15 February 2022). "Digital 2022: Indonesia". *DataReportal*.
84 Rizki, K. (17 May 2022). *How digitalization is accelerating the growth of MSMEs in Indonesia*. World Economic Forum.
85 Liu, H. and Bakara, W. (26 April 2022). "The technology trends that could turbocharge Indonesia's economy". McKinsey & Company.
86 O'Dea, S. (30 March 2022). "Smartphone users by country worldwide 2021". Statista.

In 2019, the Indonesian Government completed the Palapa Ring project to provide the country with 4G internet. The project will cover more than 35,000 km of land and sea cables and cost more than $1.5 billion. Using the 'ring', the government is aiming for a network capacity of 100 gigabits (Gbps) per second all around the country.[87]

Beyond providing connectivity, mobile technology has the reach, capability and integration in daily life to have a transformative impact on those who need it most. It can help improve the lives of families by providing better health options, distributing information for educational purposes, enhancing access to household utilities and creating opportunities to increase income.

87 Medina, A.F. (28 January 2020). "Indonesia's Palapa Ring: Bringing Connectivity to the Archipelago." *ASEAN Briefing*.

4.3 Opportunities for mobile-enabled climate technology

The rapid growth of Indonesia's mobile technology sector is unlocking opportunities for traditional and emerging industries to adopt novel and increasingly sustainable approaches to their operations. An increased interest in climate technology solutions at both the connectivity and end-user level are being met with enthusiasm from ESG-conscious innovators and attracting more investment from impact-focused investors.

All this provides a significant opportunity to expand the use of mobile-enabled technologies, leverage momentum for climate technology and embed solutions that are accessible, inclusive and have a positive impact throughout Indonesia.

Mobile-enabled technology is uniquely placed to allow the Indonesian public to adapt to climate change and enhance their mitigation efforts. From basic mobile services to big data, Internet of Things (IoT), artificial intelligence (AI) and other frontier technologies, these mobile-enabled channels offer a unique way to address Indonesia's climate challenges and an opportunity for low- and middle-income countries (LMICs) like Indonesia to leapfrog intermediate development stages while improving the quality and expanding the reach of public services.[88]

Mobile-enabled climate technology refers to any mechanism that, through the use of mobile-based devices, enables carbon emissions to be avoided or supports climate adaptation efforts. To grasp the range of possibilities offered by digital and mobile-enabled solutions to address climate change, the GSMA ClimateTech programme has developed a conceptual framework of mobile and digital assets that could be used to address central climate challenges.[89]

This framework identifies four main types of mobile and digital assets typically available to enable digital and mobile-enabled solutions for climate mitigation, adaptation and resilience:

- **Mobile services:** voice, SMS, USSD, interactive voice response (IVR), mobile apps
- **Mobile payment services:** mobile money, mobile money-enabled savings, mobile-enabled credit, mobile-enabled insurance
- **Frontier technologies:** IoT, AI, blockchain, space technologies, virtual and augmented realities, drones and robotics, big data
- **Data assets:** customer data, mobile big data (commercial microwave links, call data records, location data/location-based services, data through IoT services)[90]

The use of mobile-enabled technology has the potential to enable economic and social progress and enhance Indonesia's ability to achieve climate adaptation and mitigation objectives sustainably and inclusively. For example, mobile-enabled technology can enable data to be collected, sensors and databases to communicate, ecosystem changes to be monitored and tracked, supply chains to be optimised and the number of vehicles in traffic or weather phenomena to be predicted.[91]

The Asian Development Bank (ADB) conducted a review of digital and mobile-enabled technologies and identified a range of use cases for digital technology to assist climate mitigation and adaptation efforts. The major opportunities for mobile-enabled technology are listed in Table 4.

88 Asian Development Bank. (2021). *Digital Technologies for Climate Action, Disaster Resilience, and Environmental Sustainability: October 2021*, pp. 10–61.
89 GSMA. (2021). *The Role of Digital and Mobile-Enabled Solutions in Addressing Climate Change*, pp. 5–38.
90 Ibid.
91 Asian Development Bank. (October 2021). *Digital Technologies for Climate Action, Disaster Resilience, and Environmental Sustainability*, pp. 10–61.

Table 4

Mobile-enabled technology solutions for climate mitigation and adaptation

Technology	Climate change mitigation	Climate change adaptation
Mobile phone	Enables communication among mitigation campaigners	Tracking population migration patterns in areas affected by climate change
Database	Tracking energy consumption in a particular neighbourhood (e.g. by building type, use and time of day)	Crop failure in past years (e.g. by species, region, climate data, irrigation methods, fertilisation methods)
Satellite imagery	Assessment of emission sources (e.g. wildfires)	Assessment of land use changes due to climate change to determine adaptation options
Geographic information system (GIS)	Promoting resource efficiency (e.g. transport planning for low-carbon cities)	Crop modelling and environmental matching procedures
Apps	Calculation of an individual's carbon footprint and how to reduce it	Enable user-specific household-level adaptation metric ranks based on the user's location.
Cloud computing	Reduction needs of a company's data centre	Computing power for big data analysis for adaptation planning
IoT and smart systems	Optimising vehicle traffic in cities	Sensors to monitor soil quality in agriculture
Distributed ledger technology (DLT)	Using DLT for carbon markets (e.g. tracing and verification of emission reduction certificates)	Improving the transparency of regional authorities' climate change adaptation measurements
Robotics and unmanned vehicles	Drone-enabled production analytics for large solar farms or heat-sensing cameras to identify defective solar panels	Survey the potential for, or effectiveness of, adaptation measures in remote areas

As captured in Table 4, mobile-enabled solutions for climate mitigation, adaptation and resilience can produce a range of desirable social, environmental and economic outcomes, including:

- Lower GHGs;
- Greater resilience to the impacts of climate change for economic sectors, businesses, communities and households, including vulnerable and marginalised groups; and
- A transition to low-carbon pathways via jobs creation and inclusive employment opportunities.

Mobile-enabled technology can also provide and enable tools that can be used across many sectors for a range of applications. The GSMA has identified seven broad thematic focus areas well-suited to mobile and digital interventions for climate action:

- Clean energy and energy efficiency;
- Transport, mobility and logistics;
- Forestry and natural resource management;
- Agriculture;
- Waste management and circular economy solutions;
- Water resource management; and
- Disaster preparedness and response.

The opportunities for mobile-enabled technology to tackle climate challenges are significant and have potential to create a positive impact across a range of key sectors in Indonesia. Examples of potential use cases are highlighted in Table 5 by priority sector.

While these examples demonstrate a growing range of applications in Indonesia's mobile-enabled technology landscape, the industry is still nascent. A range of barriers are inhibiting adoption and implementation, which are discussed in the following section.

Table 5

Examples of use cases of mobile-enabled climate technology

Energy

PT Bina Lintas Usaha Ekonomi (BLUE)

BLUE provides electrification in rural areas that do not have access to electricity from PLN (the national electric power distributor in Indonesia). Initially, BLUE offered a decentralised solar home system (SHS) that included solar lighting and a phone charger, TV and fans. However, with electricity consumption increasing, they are interested in adopting a more centralised solar system in rural villages. As part of their financial billing, BLUE uses online net metering to measure household electricity usage.

BLUE uses a mobile dashboard website for remote monitoring in real time over Wi-Fi. Developers are notified of technical issues with the SHS without having to wait for the owners to report them. This helps developers tackle issues immediately and prolongs the life of the solar panels.

Ministry of Agriculture

The Ministry of Agriculture is developing climate-smart agriculture technology to anticipate climate change and minimise impacts on national food production. They also promote the use of low-carbon crops, organic materials, balanced fertilisers and emissions measurement.

Sumba Sustainable Solutions (3S)

3S uses a decentralised model to bring electrification to rural areas. Their pay-as-you-go (PAYG) services include solar lighting and productive use centres in villages. Solar lighting services provide rural households with a micro SHS (three lights, phone charger, battery and solar panel). For villages with wireless connectivity, 3S accepts PAYG payments over mobile.

Agung Podomoro Land (APLN)

With the aim to increase its market share, Indonesia's biggest property developer, APLN is planning to equip their residential properties in more than five estates with smart home technology products. Adoption has been driven by IoT technologies that allow developers to be more competitive in the real estate market and optimise energy usage and absolute savings for residential and industrial users.

Table 5 continued

Examples of use cases of mobile-enabled climate technology

Waste

Siklus Refil

Siklus Refill helps to reduce domestic plastic waste with an app that lets users select which household and kitchen products they want refilled. Personal containers are provided to customers to refill.

Waste4Change

Waste4Change is tackling the problem of increased waste in landfills, waste leakage into the environment and irresponsible waste management. Waste4Change transports and sorts waste from households and companies and then segregates the waste (organic, inorganic and residue) to be recycled. The company uses wireless digital scales for sorting and stores the data they collect in the cloud.

Gringgo

Gringgo is a mobile app for monitoring and collecting data on waste treatment in Bali. The app can be used by waste collectors to collect information on the economic value of waste or by residents to monitor and obtain information on their nearest waste facilities. The app calculates the associated value of waste through photos and AI technology. The aim is to educate users about the value of waste, increase recycling and make waste collection and processing more efficient.

Table 5 continued

Examples of use cases of mobile-enabled climate technology

Natural resource management

PetaBencana.id

PetaBencana.id is a free web-based platform that produces real-time disaster maps using crowd-sourced reporting and validation from government agencies. PetaBencana removes the need for time-consuming data processing, instead using social media and instant messages during an emergency to provide on-the-ground situational data for end users. PetaBencana.id can provide a comprehensive overview of disaster events, enabling the relevant actors and agencies to make more informed decisions during emergencies.

Aruna

Aruna is a technology company that helps to streamline the supply chain of fishery products by connecting small-scale fisheries to the global market. Aruna's integrated marine fisheries platform for seafood products helps connect fishery businesses directly to customers (export/import companies, processing companies, supermarkets, hotels and restaurants), simplifying the supply chain. This service cuts out intermediaries and allows fishers to receive a fair price for their catch. Aruna also provides GPS systems for fishing boats to keep crews safer and track their fishing methods. Aruna uses three types of technology for tracking: connectivity in the areas being tracked, a GPS system and satellite.

Jala

Jala uses IoT, sensors and machine learning technology to help shrimp farmers maximise the efficiency of their operations. IoT water monitoring devices allow farmers to receive real-time data accessible on an app anytime. Using smart technology, the software management platform gives farmers better predictions of shrimp growth and optimal harvesting time. The system also provides recommendations for farmers to prevent the loss of shrimp and improve productivity.

FishOn

FishOn is a fish-tracking app that helps fisheries collect daily information on fish position and location. This enables more productive fishing trips as fewer resources are wasted, like time and fuel. An algorithm is used to learn the feeding patterns and ecosystem characteristics of a certain area, which then provides potential locations of fish. While still on land with good access to a mobile connection, fishers can input their targeted fish species and download the data from the FishOn app, which will direct them to the best fishing location. FishOn uses two satellites (NOAA and Oceanography). Oceanography detects the presence of plankton, which is an indicator of higher numbers of fish. FishOn also conducts its own marine survey to estimate the potential catch (including fish species, the food chain and fish feeding and breeding patterns), which is then validated by users who report the type, amount and weight of fish stock caught. Currently, the accuracy rate is 85 per cent.

4.4 Barriers for mobile-enabled climate technology

Our extensive desk research and interviews with 25 stakeholders from the Indonesian Government, capital investors, start-ups, MNOs and NGOs, aim to understand the key barriers associated with the deployment of mobile-enabled climate technologies.

Broadly, these barriers can be categorised as technical, political and behavioural. These are defined in Appendix B, with barriers classified into one of these three categories. However, many barriers cut across multiple categories and are explored in more detail in this section.

Technical barriers relate to the availability of mobile and digital infrastructure and access to affordable and connected devices.

Technical barriers

Connectivity

Our desk review and stakeholder interviews consistently identified connectivity as the most significant barrier to the deployment of mobile-enabled technology in Indonesia. While connectivity is increasing throughout the country, supported by investment from government and the private sector, 94 million adults were unable to access the internet on a mobile device in 2019, and even fewer had access to mobile broadband internet.[92] Nearly 80 per cent of those who are unconnected live in rural areas of Sumatra, Java and Bali, the country's three most populous islands.[93]

Mobile-enabled climate technology solutions all require some level of remote connectivity to function, whether internet, 3G, 4G or the emerging 5G. Disparity in connectivity across Indonesia, particularly in rural and remote locations, has magnified the digital divide and continues to weaken the ability of government, the private sector and local communities to formulate a collective response to climate change mitigation and adaptation. A lack of connectivity is also a barrier for capital investors who note that while mobile-enabled solutions may have a real impact on climate change efforts, the ability for end users to access relevant solutions is limited.

Connectivity is a major challenge for start-ups and innovative technology developers, which are often restricted to areas with high connectivity to pilot or roll out applications. Alternatively, some developers and innovators will resort to manual input measures in areas with low or no connectivity to ensure they can provide their services. This lack of connectivity has downstream effects on developers, as capital providers are hesitant to invest in mobile solutions that are not viable for significant segments of the population.

92 Setiawan, I., Pape, U. and Beschorner, N. (13 May 2022). "How to bridge the gap in Indonesia's inequality in internet access". *World Bank Blogs*.
93 Ibid.

Political barriers are the political, social and ecological decisions and actions that affect decision-making about climate change or uptake of mobile-enabled technologies.

Political barriers

Collaborative environment

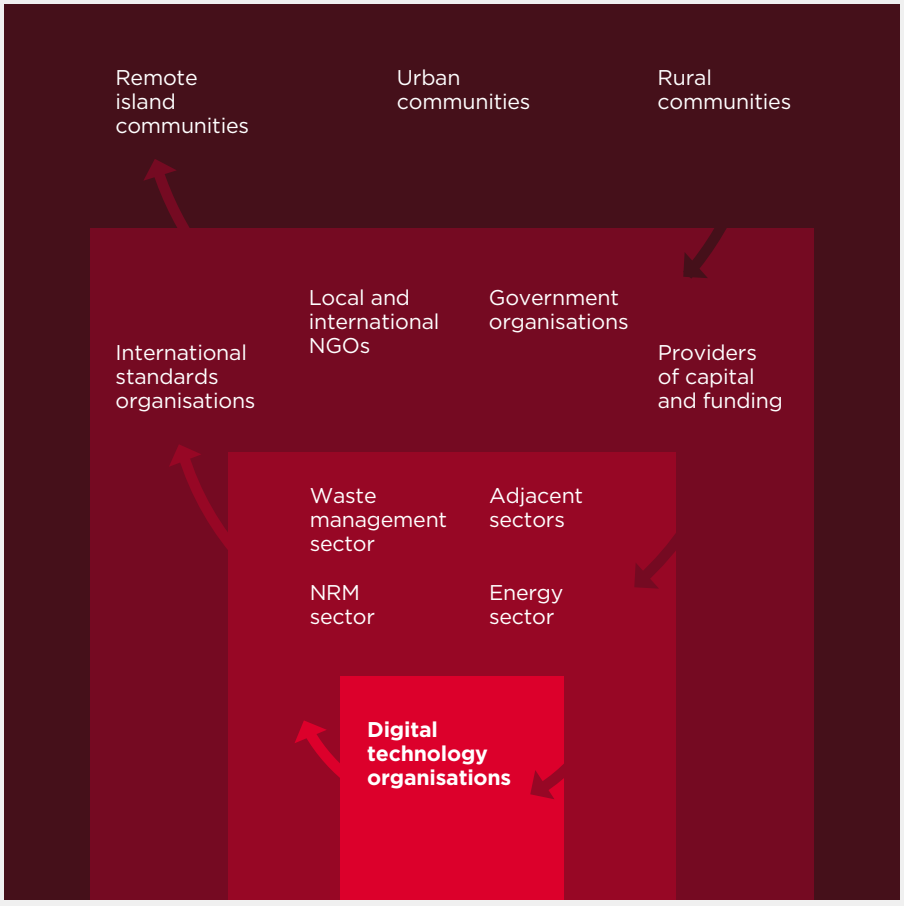
Despite a growing appetite for mobile-enabled technology solutions in Indonesia, our research indicates that limited collaboration between governments, the private sector and communities is a major barrier to growth.

Mobile innovation may start with a digital solution, but for the technology to be widely adopted and impactful, it requires multiple sectors to collaborate. For example, capital providers may support start-ups and other innovators to develop digital solutions, but without MNO infrastructure to support the roll-out of these technologies, solutions are less viable. In interviews, stakeholders described a weak collaboration environment with limited interaction among all stakeholders, stifled innovation and limited access to investment and capital. This was compounded by a hesitancy to share data across institutions.

Figure 8 captures the key stakeholders in Indonesia's digital technology landscape, highlighting the interplay that will be needed to develop relevant mobile solutions in an inclusive and collaborative way.

Figure 8

Key stakeholders in Indonesia's digital technology landscape



Local communities

- Communities living in Java and Bali (high-density community living)
- Rural communities (limited connectivity)
- Remote islands and communities (no reliable connectivity)

Enabling stakeholders
(corporate, NGOs, start-ups, government)

- Government agencies, ministries and state departments
- International standards organisations
- Local and international NGOs
- Investors: traditional providers of debt and equity; impact investors

Sector custodians
(corporate, NGOs, start-ups, government)

- Waste management sector organisations
- Energy management sector organisations
- Natural resource management sector organisations
- Adjacent sector players: agriculture, transport, retail, real estate

Digital technology stakeholders
(corporate, NGOs, start-ups, government)

- MNOs
- Tower companies
- SaaS, NaaS, OEM providers, software providers

Data sharing and management

A lack of data integration, together with data inconsistencies across government and industry sources, has contributed to a perception that data is unreliable across the public and private sectors. This discourages engagement with data sources and presents a challenge when developing mobile solutions.

Compounding this is the common practice of manual data collection and reporting in Indonesia's public and private sectors, which has reinforced the perception that data is unreliable and made it more difficult to develop or operationalise mobile-enabled solutions.

This is a challenge across the public and private sectors, with government stakeholders noting that in certain industries, low levels of reporting compliance, such as emissions data, pose a major challenge to accurate analysis and reporting.

Stakeholders also noted that government agencies' climate data sources are often disaggregated, which leads to data overlap across institutions and affects their ability to interpret data for end users.

NGOs noted that data inconsistency was a key challenge given that they often rely on publicly available data sources to design and implement interventions. Incomplete or inconsistent data was cited as a main obstacle to delivering services with the greatest social and environmental impact.

Policy and regulation

Limited policy and regulatory intervention, including a lack of policy incentives to drive climate action, are another barrier to the growth of mobile-enabled technology solutions. Limited government support for policies that enable mobile solutions, from physical infrastructure incentives to improve connectivity, to introducing privacy regulations to increase consumer trust, is seen as a critical gap limiting growth in the sector.

Weak regulation of environmental performance and management was also seen to be limiting interest in developing climate-targeted solutions. One example was low enforcement of littering, which was making mobile-enabled solution developers less willing to introduce waste management solutions.

Stakeholders also noted there is no regulation or protection for physical infrastructure, which has weakened the confidence of infrastructure providers such as telecommunication tower operators to develop digital infrastructure.

Investor appetite and access to capital

While Indonesia is experiencing significant investment in mobile-enabled technology, with considerable investment flowing to health and educational solutions, there has been limited interest in climate-focused solutions due to concerns about how to monetise them. Stakeholders indicated that while investment is growing in this space, investors have historically neglected environmental and climate innovators due to the perceived risks of monetisation and untested implementation models. The newness of companies, which are often in their early years of operation, was another factor limiting investment.

Limited intellectual property protections and permit procedures were also identified as hurdles facing innovators, with a weak regulatory environment currently presiding over intellectual property in Indonesia.

In terms of investor appetite, developers of mobile-enabled solutions noted that access to capital was a key challenge. While mobile-enabled solutions can make operations more efficient and reduce costs, the transition requires upfront capital and operational costs.

This is a major barrier for all institutions, from the public sector to utility providers to start-ups, since cost management is a central consideration and investment in innovation is just one facet of their operations. This is compounded by the high cost of capital to develop the hardware and software required to enable digital solutions, which has prompted some organisations to look abroad to minimise costs.

Talent

Limited access to critical talent to develop, roll out and monitor mobile-enabled technology solutions has also been seen to stifle progress. Stakeholders emphasised that a small talent pool with relevant skills was hampering the country's prospects for productivity. This is further complicated by an abundance of organisations in the tech industry, particularly the burgeoning e-commerce sector, seeking skilled employees and being prepared to compensate accordingly.

This challenge extends to rural areas and regions where mobile-enabled solutions require personnel on the ground to assist with promotion, roll-out and maintenance of solutions. For some organisations, limited access to rural and regional talent has led to staff being sent out from cities to operationalise solutions, an additional cost for providers.

Behavioural barriers include individual and collective assumptions, beliefs, values and worldviews that influence responses to climate change.

Behavioural barriers

Unclear value propositions

The perceived value of mobile-enabled solutions for end users has been a barrier to uptake, with some reluctant to use solutions that do not demonstrate a clear personal or environmental benefit. Concerns about privacy, data security and data mismanagement have also limited use, due to fear of being tracked or traced without consent.

Cultural factors were also found to affect the uptake of digital technologies, for example, engagement with providers of certain religious denominations or cultures.

Digital literacy

Mobile technology relies on end users being able to understand and adopt solutions at scale. Indonesia has low levels of digital literacy, with higher levels in urban areas. Stakeholders noted that digital literacy is a real challenge, particularly when rolling out solutions in remote regions where many target users have little or no ability to interact with smart devices. This has escalated costs associated with training end users to use digital solutions.

5 Theory of change

The rapid digital transformation underway in Indonesia, driven by a young and tech-savvy population, a growing middle class and the proliferation of mobile devices and technology platforms, have put Indonesia in a unique position to use mobile-enabled technology to address climate mitigation and adaptation.

Insights collected from our research have been used to develop a theory of change for mobile-enabled technology in Indonesia. It captures the causal links between potential use cases in the three focus areas of energy, waste and natural resource management, and subsequent outcomes for specific stakeholders.

The theory of change has been developed to capture generic use case scenarios. The assumptions underpinning it include enablers generally under the control of an organisation or stakeholder group, as well as externalities and challenges that affect an organisation's or stakeholder's ability to achieve the desired outcomes. Enablers are often characterised by the mechanisms that help an organisation or stakeholder group deliver on planned activities. Externalities, in contrast, are best described as social, cultural, economic and political factors, laws and regulations that need to be strategically managed to mitigate barriers and potential adverse outcomes.

The five key stakeholder groups represent the main actors involved in shaping the future landscape of mobile-enabled digital solutions. Each stakeholder group captures the types of stakeholders needed to create a holistic ecosystem.

The challenge of collaboration is, in part, aligning the motivations and desired outcomes of different stakeholders to create a shared understanding of relevant solutions. The MIH can convene these stakeholders to engage in dialogue and collaborate within the ecosystem.

The seven use cases in the theory of change can be applied across the three focus areas. The use cases provide a generic framework that can be used to identify more specific and user-centric use cases at the sector level. A similar lens has been applied to material outcomes and enables a more refined selection of material outcomes in the future. The outcomes identified are linked to nine of the United Nations Sustainable Development Goals (SDGs).

The challenges and enablers are critical considerations that affect the ability of stakeholders to achieve successful outcomes. They are therefore critical to the scalability and sustainability of a vibrant ecosystem in which innovative mobile-enabled digital solutions address climate change in Indonesia. The technical, political and behavioural challenges that could impede uptake of mobile-enabled climate technologies will need creative solutions and a multi-stakeholder approach to overcome barriers.

The five core considerations set out in Chapter 6 provide a starting point for stakeholders to assess their role in accelerating the use of mobile-enabled technologies. The theory of change framework is useful for understanding the role of each stakeholder in the ecosystem. Additional granularity will reveal the drivers, motives and challenges of each stakeholder. It provides a transparent way to address current and future barriers to fostering a collaborative environment in which key stakeholders design, pilot and deliver mobile-enabled technology solutions that have the potential to support the climate change mitigation, adaptation and resilience objectives of Indonesia.

Through the MIH, the GSMA can facilitate this deeper examination of the theory of change framework and clarify opportunities for each stakeholder group to work together to achieve meaningful outcomes.

Figure 9

The theory of change framework with use cases, outcomes, challenges and impacts of mobile-enabled climate technologies

Key stakeholders

Digital technology organisations

- MNOs
- Tower and infrastructure providers
- SaaS, NaaS
- OEM and connected device manufacturers
- Software and data server solution providers

Focus (private) sectors and start-ups

- Waste management sector organisations
- Energy management sector organisations
- Natural resource management sector organisations
- Adjacent sector players: agriculture, transport, retail, real estate
- Start-ups and incubators

Local communities

- Citizens
- Community organisations or cooperatives
- Civil society organisations
- Organised (informal) collectives

Government

- Government agencies, ministries and state departments
- Local government bodies and entities
- Telecommunications regulator
- Energy regulator
- Waste management authorities

Providers of capital and NGOs

- Investors: traditional providers of debt and equity; impact investors
- Local and international NGOs
- International standards organisations

Impact pathways

Use case categories and generic activity areas

WASTE MANAGEMENT | ENERGY MANAGEMENT | NATURAL RESOURCE MANAGEMENT

CATEGORY 1
Technologies and connected devices for monitoring and data collection

1. Data collection using connected devices to support decision-making
2. Services and solutions to reduce harmful and/or illegal activities
3. Services and solutions to improve productivity and reduce carbon-intensive activities

CATEGORY 2
Technologies for community engagement

4. Use of technologies to influence positive behaviour change and community engagement in sector-specific activities
5. Provision of tools and solutions to local communities and local governments to improve procedures, governance and planning
6. Facilitation of payment for services using mobile payment platforms to incentivise communities to support sector-specific initiatives and objectives

CATEGORY 3
Technologies for data storage, visualisation and analysis

7. Use of AI and data visualisation tools to aid decision-making and support better sector-specific programme outcomes

High-level material outcomes by stakeholder group

Digital technology organisations:

- Improved commercial viability of using technology to address climate change
- Improved brand affinity and relationships with stakeholders
- Improved engagement in waste management, clean energy management and natural resource management
- Improved livelihoods, well-being and safety
- Greater resilience to climate changes or hazards

Focus sectors and start-ups:

- Percentage increase in successful social and environmental outcomes
- Increase in the number of start-ups able to successfully attract investment and scale
- Improved tech-related skills and capabilities
- Improved safety of personnel
- Misuse of data or technology that leads to harm*

Local communities:

- Improved awareness and understanding of climate challenges, risks and costs
- Improved access to mobile technologies that address opportunities in the three sectors

Government:

- Enhanced capacity of the government sector to engage and facilitate climate technology
- Increase in funding for climate technology projects
- Improved governance and reduced (displaced) corruption
- Improved evidence-based performance on climate and SDG targets

Providers of capital and NGOs:

- Rise in investment opportunities in climate technology

*Negative/unintended outcomes that need to be managed with adequate investment and built-in safeguards to mitigate risks.

Long term alignment with SDGs

The long-term impacts and outcomes of the seven use case scenarios align with nine SDGs and targets.

Key challenges

- **Connectivity issues:** Mobile coverage and penetration gaps, particularly in remote regions, impedes the ability to deploy mobile-enabled climate technology solutions in Indonesia. The lack of energy (electricity) in some remote areas exacerbates this challenge.
- **Unclear value proposition for end users:** Unclear incentives for end users result in suboptimal adoption and stickiness of solutions, leading to challenges with scalability and replication of services, and thereby commercial viability.
- **Inadequate collaboration:** The opportunity to leverage technology solutions that address climate change requires a participatory multi-stakeholder approach. There is a need for collective action to develop innovative mobile-enabled technology solutions.
- **Investment in mobile-enabled climate technologies:** Commercially viable business models that support the use of mobile-enabled technologies to address climate change are still nascent and can be prohibitive for potential investors.
- **Consistent policy:** There is a need to review and align government policies that promote investment and adoption of technologies to address climate change mitigation and adaptation.

Key enablers

- **Vibrant start-up ecosystem:** The start-up ecosystem in Indonesia is growing exponentially and provides an ideal foundation for innovative and user-centric mobile-enabled climate technology solutions to be incubated and launched.
- **The desire to create a shared vision:** There is a strong desire among all stakeholders to collaborate and develop a shared understanding of the climate emergency and the collective response required to address opportunities in the three focus sectors.

6 Opportunities to accelerate mobile-enabled technology in Indonesia

There is an opportunity in Indonesia to leverage the country's digital assets and wireless technology infrastructure to address the climate emergency.

However, the ability of mobile-enabled technologies to deliver effective outcomes and have a positive impact on climate mitigation and adaptation will depend largely on addressing the following five considerations.

Through our research and discussions with key stakeholders, the following five considerations emerged as critical enablers to accelerate the adoption and scale of digital solutions to address climate mitigation and adaptation in the waste, energy and natural resource management sectors. These considerations are likely to evolve and mature organically in response to risk mitigation, commercial opportunities and policy regulation. There is, however, an opportunity for the GSMA and the stakeholders in our research to jumpstart the process.

Technical considerations

Consideration 1
Investment in infrastructure for mobile-enabled technology is vital to unlocking opportunities.

The need for connectivity coverage and penetration, particularly in remote areas and certain regions, was cited as a significant barrier to mobile access. The need to improve connectivity in parts of Indonesia where issues of waste management, energy and natural resource management need to be addressed was a consistent theme in stakeholder interviews. Given this reality, infrastructure providers and investors, including the government, need to invest meaningfully in infrastructure that could unlock the potential of mobile-enabled technologies.

Further research into the commercial viability of mobile-enabled technologies that address climate change mitigation and adaptation is required to support a risk-adjusted investment case. The outcomes and modelling of the findings will also create an opportunity for MNOs, governments and other key stakeholders to find new ways to collaborate on favourable community outcomes.

Box 1

Project concept: Self-sustaining base station site

Challenge

- Indonesia has more than 17,000 islands, and most remote islands still do not have access to the national grid.
- MNOs often struggle to set up base stations in these locations. Having a diesel generator to power the site would add to the logistical challenges and produce a large environmental footprint.
- Even after connecting these remote islands, there would still be a significant usage gap for communities that would not find connectivity solutions accessible.

Context and opportunity

To extend connectivity to the last mile, the Telecommunication and Information Accessibility Agency (BAKTI), under the Ministry of Communication and Information Technology (MoCaIT), sets up mobile base stations powered by renewable energy in remote island locations. MNOs could take over tower operations from BAKTI, and communities that are added to the MNO network could use digital technology solutions to better adapt to the impacts of climate change.

Project idea

Pilot a partnership model with an MNO using a new tower to power relevant technology solutions (IoT, big data, AI, etc.) that strengthen the anticipatory and adaptive capacity of communities to address climate change. An interactive, user-focused capacity building programme could be introduced to adopt these solutions.

Political considerations

Consideration 2
Build confidence in the viability of mobile-enabled technology

Support for mobile-enabled technology among key stakeholders is currently mixed. For example, a growing start-up industry is being met by investors concerned about the viability of mobile-enabled solutions due to limited connectivity, relevance for end users and policy issues. This is stifling investment and, ultimately, producing suboptimal outcomes for end users who could reap meaningful benefits.

There is, therefore, a need to raise awareness of, and build confidence in, the opportunities that mobile-enabled technology offers both providers and end users. This will likely require coordination among all stakeholders (see Figure 8). For technology providers and MNOs in particular, the investment required to scale digital technologies with nascent commercial models is prohibitive and challenging. There is an opportunity to review mobile innovations that have reached scale in other nascent areas of development and environmental intervention. The lessons could be compiled for key stakeholders in the form of a toolkit or playbook that detail the conditions for effective results and scale.

Consideration 3
Foster collaboration and knowledge building

Inadequate collaboration across key sectors and stakeholders hampers their ability to develop innovative mobile-enabled technology solutions. Multiple sectors need to enhance collaboration to build momentum for these solutions, which in turn will build the confidence of government and institutional investors. Stakeholders interviewed for this research expressed the need for greater collaboration and rules of engagement around data collection, data collation and data sharing across government agencies and levels of government. This is particularly relevant in Indonesia's energy and waste sectors where supply and distribution chains span multiple levels of government.

Awareness and knowledge at the institutional level were considered crucial to fostering a collaborative ethos. Organisations from every stakeholder group acknowledged the need for digital literacy and competency and understanding the climate emergency. The absence of a shared understanding due to varying levels of digital literacy and climate knowledge was identified as an inhibitor to progress and collaboration.

Conversations with stakeholders from all sectors provided an opportunity to gather insights on their desire and appetite to convene as a group, to create a shared understanding and set long-term goals to use technology to address the climate emergency. Stakeholders were keen to share their views and identified areas where more collaboration was needed to advance their work and strengthen their impact. A creative ideation workshop convened as part of the research brought stakeholders together and was seen as helpful in validating the need for greater dialogue and identifying opportunities for cross-sector collaboration.

It is vital to create a science-based narrative of a common future with outcomes that resonate with all key stakeholders. In interviews, stakeholders supported the idea that advocacy could take the shape of a collective impact model, with a convenor from government or the private sector facilitating meaningful collaboration. Building a collaborative environment is also likely to draw on stakeholders' core strengths and capabilities and accelerate the knowledge and institutional capacity required to expedite climate change adaptation and mitigation solutions in the three focus sectors.

Consideration 4
Build the capacity of community and local government

The multi-stakeholder engagement conducted for this research study showed that software, connectivity and investments alone were not enough for mobile-enabled technologies in Indonesia to address climate change successfully. It was widely acknowledged that connectivity was fundamental to digital empowerment, and that wireless connectivity was a particularly inclusive type of connectivity that had the potential to include and empower different groups, overcome socio-economic boundaries and support economic competition. Building capacity in communities and local government was also seen as critical to success.

Capacity building can be both formal and informal. For example, the creation of an innovation hub could support demand-driven innovation by grassroots entrepreneurs and, in turn, facilitate low-cost, high-value solutions as proof-of-concept models that benefit everyone.

Behavioural considerations

Consideration 5
Ensure the value proposition is clear for consumers and the perceived risk is minimal

A core barrier to uptake of mobile-enabled solutions is its perceived value. In interviews with start-ups, they indicated that in some instances end users did not recognise the value of using the mobile-enabled solutions, either for themselves or the broader public. When user data was part of a mobile-enabled solution, they were hesitant to use it out of concern for their privacy.

It is therefore necessary to ensure that the value proposition for end users, such as members of local communities, is clearly communicated and understood. The implications of using technological solutions for their personal data also need to be communicated to manage their expectations.

A human-centred design (HCD) approach could play a pivotal role in the user experience and acceptance of the value proposition. HCD would help ensure that mobile-enabled climate technology solutions are designed with inclusion, relevance, replicability, scalability, and the user's contextual and behavioural attributes in mind.

Box 2

Project concept: Digitising waste management

Challenge

- Indonesia generates approximately 38 million tonnes of municipal waste and 7.1 million tonnes of plastic waste annually, with 4.4 million tonnes of plastic waste mismanaged each year.
- Given the scale of the challenge, there are multiple government agencies and ministries actively managing municipal waste.

Context and opportunity

Reliable and rich data on the waste sector is vital to improve transparency and the circular economy of a region. Robust data informs effective waste management strategies and municipal and national policies, allowing policymakers to identify successes and where improvements are needed. However, producing good data is challenging when data sources, such as waste banks, material recovery facilities (TPS 3R), temporary disposal sites (TPS) and landfills (TPA) are manually operated. In most of these facilities there are practical challenges to data entry as most systems are Excel-based and carry the risk of data duplication. This is exacerbated by the potential errors made by low-skilled workers and different standards for how data should be collected.

Project idea

Pilot a mobile-enabled data management tool that could be integrated with other datasets in the same municipality and provide a mobile interface that enables users to update the database using their mobile phones. Clear guidance and training in digital literacy and climate change for users and public sector managers would raise awareness of the importance of their roles and the importance of data management. Lessons from one pilot could help to scale this solution into other municipalities.

Box 3

Project concept: Digital solutions for mangrove conservation and sustainable shrimp farming

Challenge

- Although Indonesia has around 3 million ha of mangrove forests, these ecosystems are increasingly at risk due to human activity. Over the last three decades, more than 40 per cent of mangrove cover has been lost due to rapid economic and population growth and an increase in both illegal and legal fishing activities.
- Traditional shrimp farmers clear large areas of mangrove forest because they believe that mangroves have a negative impact on their harvest.

Context and opportunity

Since mangrove forests are essential for the climate and the environment, mangrove forests have been an important part of the livelihoods of coastal communities. Even though the community understands the importance of mangroves, there is minimal conservation management.

In North Kalimantan, Indonesia, stakeholders such as the central government, regional government, NGOs, and the private sector have collaborated on projects that raise community awareness of mangrove conservation. The Indonesian Government has initiated a movement to plant and regrow mangroves while actively seeking the participation of the private sector with innovations and solutions.

Some proven cases of mobile-enabled climate technology have already been identified. For example, Ericsson has successfully used IoT technology to support mangrove conservation in Malaysia and Philippines through the Ericsson Connected Mangrove Program. Start-ups with proven technology for sustainable and eco-friendly shrimp farming practices have also been identified. These initiatives are considered potential opportunities to strengthen mangrove conservation efforts and reduce the negative impacts of shrimp farming on the mangrove ecosystem.

Project idea

Pilot a shrimp farming plot where technical, political and behavioural barriers are addressed via community engagement and user-centric digital solutions. A climate and digital literacy programme would build capacity in the community and help them take the first step. Involving communities in mangrove reforestation and using digital solutions such as IoT for shrimp farming, would demonstrate the positive effects of digital technology.

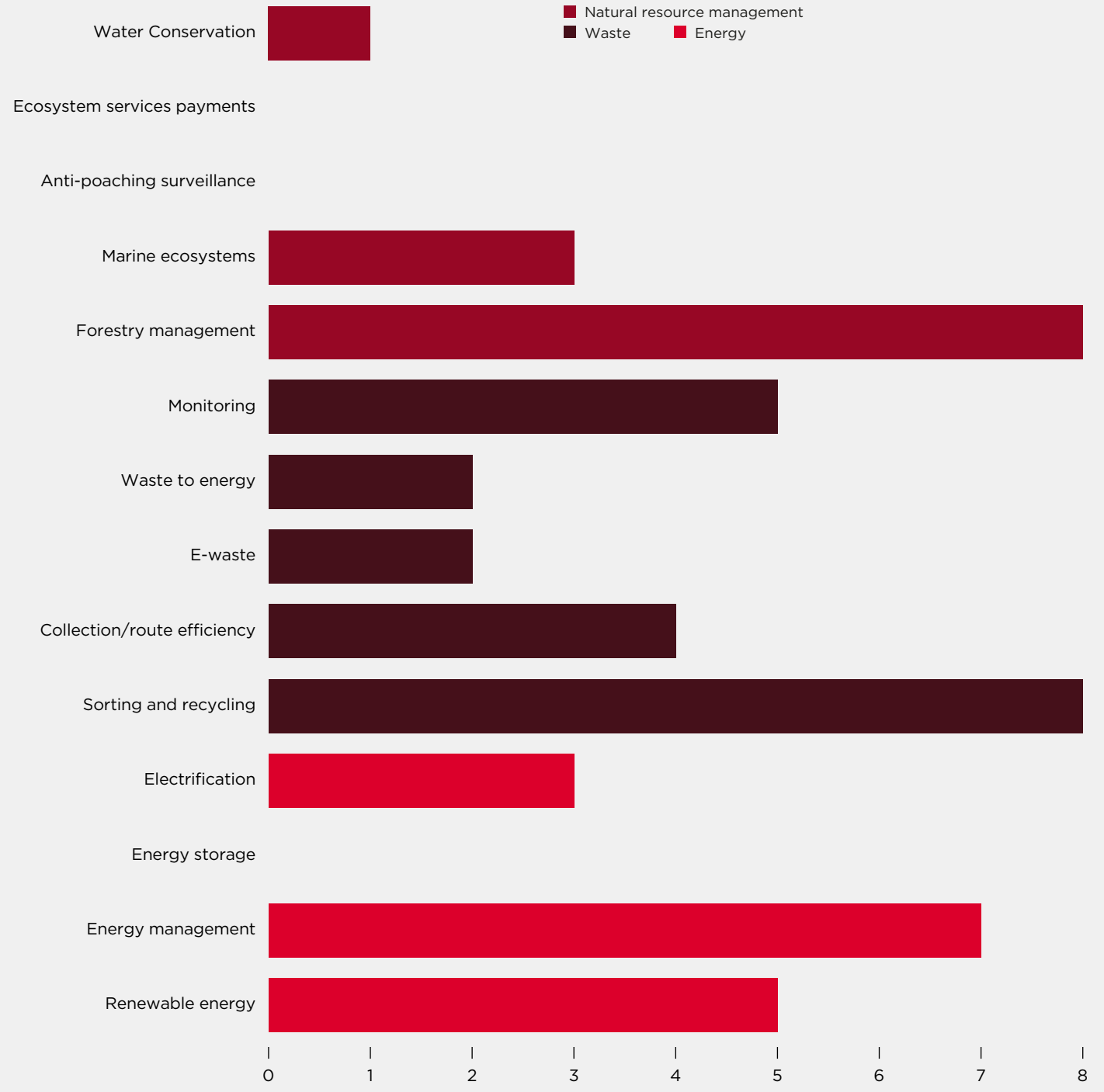
Appendices

Appendix A
Climate technology framework results

Literature review findings

Incidence of mobile-enabled climate technologies in indonesia

A Boolean search was conducted to identify sources for the climate technology framework. Search terms in both English and Bahasa Indonesia were used to guide the research.



Appendix B
Glossary of terms

Glossary of terms

Term	Definition
Smart machine-to-machine (M2M) technologies	The direct communication of devices to exchange information and perform actions with each other, including both wired and wireless, without human intervention.
Sensor technologies	These technologies gain information by detecting physical, chemical or biological properties and converting them into readable electronic signals.
Blockchain	A distributed ledger or database that facilitates the process of recording transactions and tracking assets within a computer network.
Artificial intelligence (AI)	The programming of machines and computers to mimic the intelligence, including problem-solving and decision-making capabilities and processes, of the human mind.
Call centres	Typically large centres, either centralised or remote, that receive a large volume of calls, both inbound and outbound.
Interactive content	Any type of content that encourages and allows for user participation and engagement.
Peer-to-peer technology	A network that puts individuals in direct contact with each other through two or more connected computers, which can then share resources and content with one another.
Push content	Push content or media is a strategy whereby products are suggested to a user/ customer with little interaction, as requested by the publisher.
Data collection tools	Software programs that are designed to gather and analyse data and information for the user.
Inventory management tools	Software that automates aspects of inventory and warehouse management processes by streamlining the tasks required to track inventory and update accounting data.
Mobile payments	Payments made for a product or service with a portable electronic device, i.e. a mobile phone or tablet.
Niche devices	Products designed for a small and a specific area of the technology market. Examples include drones, satellites and e-commerce platforms.
Handsets	Refers to a mobile phone device.
Networked devices	Physical devices that are connected for communication and interaction between hardware on a computer network. For example, modems, routers and switches.
Technology infrastructure	The infrastructure related to the hardware, network resources and services required for the development, maintenance and management of an IT environment.
Software	Programs and operating system used by a machine, usually a computer, to execute specific tasks.

Appendix C Barriers

Barriers

Technical

The availability of mobile and digital infrastructure and access to affordable and connected devices

Connectivity

While connectivity is expanding in Indonesia, it is inadequate to support the needs of the emerging mobile-enabled technology marketplace, particularly in remote regions.

Political

The political, social and ecological decisions and actions that affect climate change decision-making or uptake of mobile-enabled technologies

Collaborative environment

Limited collaboration between governments, the private sector and communities.

Data sharing and management

A lack of data integration and manual data collection processes have led to data reliability issues.

Policy and regulation

Lack of policy incentives and weak regulations dampen enthusiasm to develop meaningful and effective mobile-enabled digital solutions.

Investor appetite

Investments in Indonesia focus on technology in general rather than climate specifically, due to concerns about the viability of solutions.

Access to capital

Weak investment appetite is leading to low access to capital for organisations seeking to embed innovative mobile-enabled solutions.

Talent

Limited access to critical talent to develop, roll out and monitor mobile-enabled technology solutions is slowing progress.

Behavioural

The individual and collective assumptions, beliefs, values and worldviews influencing climate change responses

Unclear value propositions

An inability to demonstrate the value proposition to end users, coupled with cultural barriers to using mobile-enabled solutions, are stifling uptake.

Digital literacy

Digital literacy is a key barrier for some end users interacting with mobile enabled devices, leading to suboptimal use or the need to embed back up manual methods to support these individuals when rolling out solutions

Appendix D Stakeholder interviews

Stakeholder interviews

Start-ups

- Siklus Refill Indonesia
- Khazanah Hijau Indonesia, Rekosistem
- FishOn
- Waste4Change
- Sumba Sustainable Solutions
- Aruna
- Carbon Addons
- Bina Lintas Usaha Ekonomi (BLUE)
- Jala

Government

- Direktorat Jenderal Energi Terbarukan dan Konservasi Energi (DJEBTKE), KESDM
  Directorate-General of New Renewable Energy and Energy Conservation (DGEBTKE) under the Ministry of Energy and Mineral Resources (MEMR)
- Direktorat Jenderal Pengelolaan Sampah, Limbah, Bahan Beracun dan Berbahaya (PSLB3), KLHK
  Directorate-General of Waste, Hazardous, Toxic and Waste Management (PSLB3) under the Ministry of Environment and Forestry (MoEF)
- Direktorat Jenderal Ketenagalistrikan, KESDM
  Directorate General of Electricity under the Ministry of Energy and Mineral Resources (MEMR)
- Direktorat Jenderal Pengendalian Perubahan Iklim (DJPPI), KLHK
  Directorate General of Climate Change Control under the Ministry of Environment and Forestry (MoEF)
- Bidang Perencanaan dan Evaluasi Badan Restorasi Gambut dan Rehabilitasi Mangrove, BRGM
  Planning and Evaluation Division under the Peatland and Mangrove Restoration Agency (BRGM)
- Direktorat Perencanaan Ruang Laut, KKP
  Directorate of Marine Spatial Planning under the Ministry of Marine Affairs and Fisheries (MoAaF)
- BAKTI Kominfo
  Telecommunication and Information Accessibility Agency under the Ministry of Communication and Information Technology (MoCaIT)

MNOs

- XL Axiata
- Indosat Ooredoo Hutchison (IOH)

Utilities (PLN/state-owned electricity company)

- Perusahaan Listrik Negara (PLN)

NGOs

- World Resources Institute (WRI)

Incubators

- Ecoxyztem
- PT New Energy Nexus Indonesia

Utilities (tower infrastructure company)

- Moratelindo

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