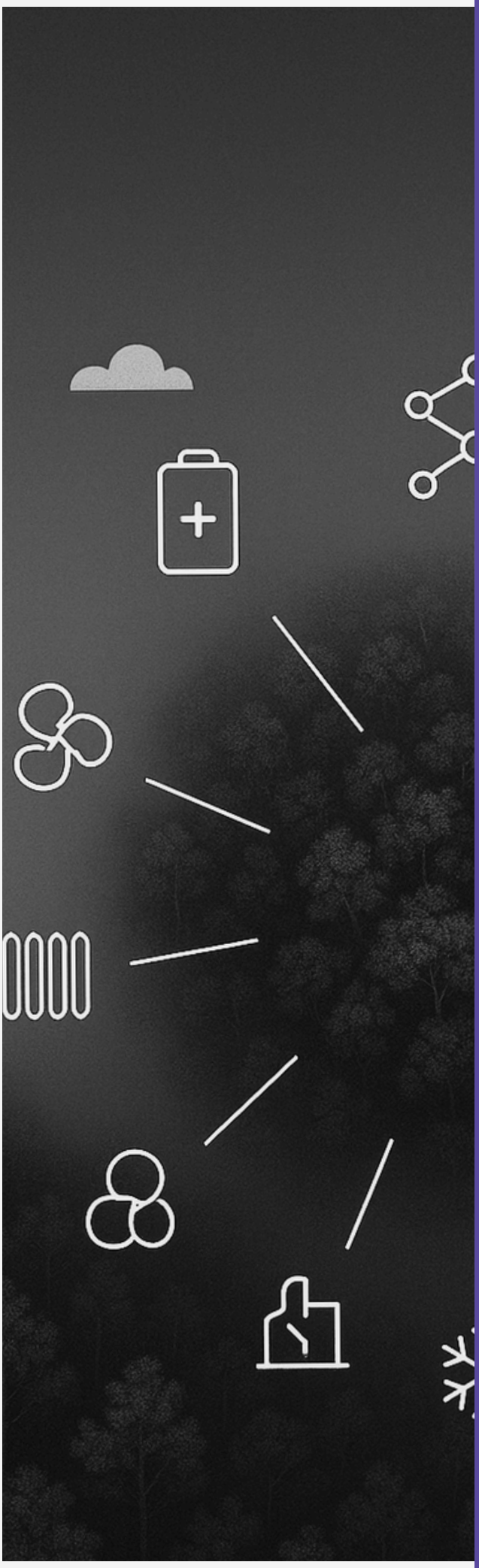

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Scaling Climate Tech Solutions

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Learnings & Reflections

Over the years, **Intellecap's** engagement with 350+ climate-tech startups and projects globally, has yielded valuable insights and reflections on scaling innovations that contribute to climate mitigation and adaptation. These learnings encompass a deeper understanding of emerging climate technologies as well as the evolving business, financing, and market needs specific to each stage of entrepreneurial growth. Our work has helped us build a deep reservoir of knowledge about the relevant markets for these niche technologies, a diverse network of partners in the APAC and Africa regions; innovative business models, and relevant pools of capital and financing mechanisms for scaling these technologies and solutions in the Global South. This paper aims to distil and share these insights, providing guidance for stakeholders seeking to advance such solutions.

Emerging climate technologies & solutions

Technology areas	Type of technologies
Energy storage	**Electrochemical storage:** Lithium-ion batteries, Flow batteries; Battery management and recycling technologies to enhance efficiency and sustainability **Mechanical storage:** Flywheels, Gravity-based storage (solid mass elevation and release) **Others:** Battolyzers, Swappable solar-charged batteries; mesoporous carbons made from bio-waste to extend battery life of lead acid batteries; range extenders for EVs
Smart green grids	**Decentralized micro-grids**: Modular renewable energy microgrids including hybrid solar and bioenergy based micro grids, solar and micro hydro micro grids, solar hydrogen micro grids, sea wave energy powered microgrids, biogas based micro grids etc. designed for rural, off-grid, and peri-urban communities. **Advanced metering infrastructure (AMI):** Smart meters and prepayment systems enabling accurate billing, load management, and customer data analytics to improve financial sustainability and user engagement. **Grid integration solutions:** Technologies that manage variable renewable energy inputs and support grid stabilization, including inverters, energy management systems, and virtual power plants facilitating distributed energy resources aggregation.

Technology areas	Type of technologies
Biomass, Biofuels & Waste to Energy	**Biofuel production innovations** (e.g. producing biodiesel using fish waste) **Waste to energy conversion technologies** (e.g. producing biogas form rice straw) **Advanced anaerobic digestion systems**
Energy management systems	**IoT-based energy management system:** End-to-end smart energy platform for commercial buildings and businesses that monitors electricity, gas, and water use in real-time. **Community energy trading platforms and battery control systems:** Smart trading platforms combined with battery control technology to enable peer-to-peer energy trading in microgrid and off-grid community settings
Low carbon hydrogen	**Green hydrogen production and storage:** Electrolyzers powered by renewable energy sources (solar, wind, hydro) that produce hydrogen through water splitting with zero carbon emissions
Clean cooking	**Solar thermal cooking, CSP powered clean cooking solutions** **Anaerobic digestors** to generate biogas for cooking **Biomass pellet based forced draft** clean cookstoves
Pump and pumping systems	**Solar water irrigation pumps** (e.g. piston driven submersible pump sets for irrigation; portable submersible solar pumps etc.)

Technology areas	Type of technologies
Sustainable cooling	**Solar powered sustainable cooling appliances** **Mobile solar-powered vaccine coolers** and cold chain solutions **Solar powered cold storage units** **Passive and active solar cooling systems** **Phase Change Materials (PCM)** for cold storage **Refrigeration systems powered by biomass and farm waste**
Waste Heat Recovery	**Regenerative burner systems** **WHR systems for the Textile Dyeing** **Tunnel Furnaces for steel re-rolling mills**
Industrial resource efficiency technologies	**Biodegradable plastics** (e.g. bioplastics made from a unique blend of starch; Ocean-safe seaweed films etc.) **Sustainable packaging material** (material made from upcycling of agricultural waste and mushroom mycelium.) **Battery recycling** (e.g. Hybrid Hydrometallurgy Process (HHP) that recycles various types of lithium-ion batteries)
Others	**Solar-powered thermal and heating devices using battery storage** to provide localized heating for health or comfort applications in off-grid settings **PV thin-film technologies** **Portable and scalable solar generation platforms** designed for industrial and rural electrification with remote monitoring and control **IoT-enabled smart monitoring and management platforms for DRE** **Hybrid floating solar PV combined with in-stream tidal energy generation** to optimize clean electricity production from water and solar sources **New commercial solar business models** such as rental, franchising, energy-as-a-service, pay-as-you-go financing aimed at scaling solar technologies **Insetting platforms**

Recommended strategies to scale climate-tech innovations

Climate-tech innovations grapple with various affordability, market and investment barriers that hinder their growth. Our learnings from different programs highlight several ways to address these barriers and expedite commercialization and scale-up efforts.

Addressing affordability barriers

As many climate technologies target low- and middle-income consumers and SMEs in off grid or weak grid areas, ensuring end user affordability becomes critical to drive adoption and usage. Startups that can demonstrate how their innovation reduces costs compared to existing alternatives or doing nothing, and how it provides value for money, are better positioned to raise both grant and commercial capital. Intellecap has supported various innovators and startups by developing or validating innovative business and end user financing models that can improve affordability.

The following section presents our learnings on how climate-tech businesses drive affordability through product and end user financing innovation.

Reducing cost through product innovation:

Many innovations are designed to reduce the cost burden on the end consumer and can potentially serve as cheaper alternatives to existing solutions or substitutes in the Global South markets.

EXAMPLES

Energy storage and resource efficiency

- **Battery recycling technologies:** Novel lead-acid battery recycling processes can significantly reduce battery replacement costs and environmental waste.
- **Thermal energy storage or thermal batteries for cooling:** Thermal batteries can reduce dependence on costly electrical batteries by using phase change materials (PCM) to store cold, maintaining low temperatures even without power. This technology lowers the cost of solar-powered refrigeration setups and improves durability and resilience, especially in off-grid or weak-grid areas.
- **Sodium-ion batteries:** Sodium-ion batteries can serve as lower-cost alternatives to lithium-ion batteries, using more abundant sodium for energy storage.

Smart green grids

Many hybrid microgrid/RE projects can improve affordability primarily by replacing or supplementing traditional battery storage with alternative energy storage or management technologies that reduce capital expenditure (CapEx) and operational costs. Examples include:

- **Use of innovative hybrid systems** that integrate solar PV with other storage options such as biomass, hydro, hydrogen, or repurposed batteries, which can reduce reliance on expensive lithium-ion batteries
- **Implementation of intelligent energy management and AI/cloud-based monitoring platforms** that optimize energy use and reduce battery capacity requirements.

Improving affordability through innovative end user financing models:

Innovative financing models such as pay-as-you-go, energy-as-a-service, ESCO, lease to own, end-user credit among others play a vital role in driving adoption in low-income and off-grid markets, by improving access and affordability.

Pay as you go and pay per use

PAYGO systems enable users to pay for products and services through small, manageable installments over time, easing the financial strain of upfront expenses. The delivery of PAYGO varies based on the market, mobile network, and level of technology available.

EXAMPLES

- **A Uganda-based solar energy solution provider offers a solar-powered irrigation pump designed to provide an affordable solution for low-income subsistence farmers** who previously could not afford high-cost solar systems. This innovation has the potential to boost crop yields while eliminating the fuel expenses associated with diesel pumps. The company's mobile pay-as-you-go (PAYGO) system gives farmers different flexible payment options for accessing the pump. These include a) using the pump as a prepaid service, paying a fee per litre that covers lifetime maintenance and irrigation training and b) acquiring the pump through a lease-to-own plan, starting with a low deposit followed by affordable monthly installments.
- **A battery technology startup in Africa offers a pay-per-use battery sharing platform for off-grid households**. Customers rent centrally charged batteries, avoiding high upfront costs for energy and enabling flexible, affordable energy access without requiring deposit, credit check or fixed payment structure or any burden of regular required payments. The company deploys agents who buy credits through mobile money to activate the batteries, which are then rented to customers at a slightly higher price, with payments accepted in cash or via mobile money.

Energy as a service (EaaS)

EaaS is a business model where energy solutions—including power delivery, heating, cooling, renewable systems, and efficiency upgrades—are provided on a subscription or pay-per-use basis, rather than through direct ownership of infrastructure. Customers benefit from predictable costs, zero upfront capital expenditure, and guaranteed energy performance. The model shifts risk management (maintenance, upgrades, regulatory changes etc.) to the service provider, enabling faster uptake of clean energy technologies.

EXAMPLES

- **The German company, Enpal, provides solar systems-as-a-service where homeowners have the option to rent durable solar modules that generate cheap PV power for at least 20 years.** The company also provides an energy storage device, a wallbox and an app to track yield, consumption, feed in tariffs etc. on request. The customers pay a fixed monthly fee for the solar energy system, while the company takes care of maintenance and repair.
- **Ecozen solutions in India offers cold storage and irrigation systems enabling small farmers to procure these systems as a service rather than products.** Farmers can lease the cold storage units for specific durations, paying a monthly fee, allowing the equipment to be efficiently utilized and shared across multiple users throughout the year. They can also pay per use based on the volume stored. These service-based models provide farmers access to advanced solar cooling technology combined with ongoing maintenance, remote monitoring, and technical support provided by the company.

ESCO (Energy Service Company)

An ESCO provides a range of energy-related services, including energy audits, project design, retrofitting, and implementation of energy efficiency measures, often on a performance-based contract basis. The model enables facility owners or organizations to improve energy efficiency without high upfront capital costs, as the ESCO finances, installs, operates, and maintains the energy-saving equipment, earning revenue primarily through shared or guaranteed savings.

EXAMPLES

- **ENCON Thermal Energies in India has adopted an ESCO model for industrial combustion systems like regenerative and self-recuperative burners for industries such as steel and aluminium.** ENCON installs its system at its own expense, including regenerative burners, controls, and integration. Clients are only required to pay a minimal project mobilization fee, which is significantly lower than traditional CAPEX costs. ENCON recovers its investment through the fuel savings generated by the system, leading to immediate benefits such as reduced furnace fuel bills, lower emissions, and improved furnace performance. At any point, clients have the option to purchase the system outright at attractive rates.

Lease to own

The lease to own model enables low-income households or small businesses to acquire climate solutions through affordable deposits and monthly installments, thus expanding market reach. This model is widely applied in distributed solar home systems, clean cookstoves, electric appliances, and microgrid connections across Africa, South Asia, and Southeast Asia.

EXAMPLES

- **Various clean cookstove manufacturers such as Sistema Bio, Burn Manufacturing, Powerstove etc.** provide clean cookstoves on lease to own terms.
- **A few mini-grid or micro-grid developers finance and procure electrical equipment locally and provide them on lease to own terms to their customers for household or business use to optimize load and revenue for the mini/micro-grid.** The equipment serves as collateral during the payment period. In cases of default, options include repossession of the equipment, disconnection of electricity, or adjustment of payment terms to encourage users to complete repayments.

End user credit models

Many clean energy solution providers sell their products on credit. The process is typically facilitated by a third party, a financial institution (FI) or micro-finance institution (MFI). The energy provider partners with the FI or MFI, which then establishes a financial product/credit scheme to lend directly to end-users, enabling them to acquire the provider's products.

In India, organizations like Dharma Life and Frontier Markets leverage a network of women entrepreneurs who serve as last-mile distributors of clean energy products. They collaborate with MFIs to offer these products on credit to low-income rural customers. Customers can pay small deposits and monthly installments, and products serve as collateral during the tenure.

Carbon financing

Over the last few years, carbon finance has played a significant role for climate-tech players to meet their funding needs and drive affordability for end users. For example, Burn Manufacturing, a leading cleaner cookstove manufacturer and project developer raised US$37m through the sale of carbon credits in 2022, which allowed it to scale and increase its capacity, and subsidize the cost of its stoves, making them available at an affordable rate to consumers.

Improving market access

Improving market access for climate-tech innovations in the Global South hinges on three important strategies: building strategic local partnerships, developing robust local infrastructure and supply chains, and understanding the local policy and regulatory landscape. These approaches enable entrepreneurs to effectively navigate complex markets by leveraging established distribution networks, tailoring solutions to local needs, reducing dependence on imports, and aligning with regulatory frameworks that govern climate mitigation and adaptation projects. Each strategy addresses unique barriers and creates opportunities for scaling climate technologies in challenging environments.

- **Building strategic local partnerships:** While accessing markets in the Global South, entrepreneurs/innovators benefit from consortiums and strategic partnerships with local distributors, NGOs, universities, governments, and commercial actors to leverage established channels and tailor technical solutions to real market needs and regulatory realities.

- **Developing local infrastructure and supply chain:** Developing robust local infrastructure and supply chains is vital for scaling clean energy innovations in the Global South. The supply chain disruptions due to external shocks like Covid 19 re-emphasised this need more than ever. Reliable supply chains for manufacturing, assembly, distribution, installation, and maintenance reduce dependence on imports and external suppliers, lowering costs and lead times, and increasing resilience to external shocks. Local infrastructure development — such as manufacturing plants, skilled labour pools, transport networks, and service centres — anchors climate solutions within regional economies, creating jobs and stimulating economic growth.

- **Understanding the local policy and regulatory landscape:** Understanding local policies is critical because policies shape the regulatory environment, market incentives, and operational frameworks that determine whether an innovation can be deployed sustainably and at scale. Aligning projects with regional policy priorities builds supportive partnerships and can unlock financing or technical assistance. A few important aspects to consider include the following:

    - **Understanding and navigating local licensing, permitting, and standards is necessary to legally operate and avoid project delays or shutdowns.** To navigate this challenge, many startups and innovators establish local partnerships with players who have secured such licenses/permits before or have access to local government agencies to better understand the regulatory requirements and processes.
    - **Monitoring local tariff regulations, subsidy availability, tax policies, and import duties is crucial.** These factors can significantly influence project economics and investor confidence.
    - **Policies governing grid extension, mini-grid interconnection, and energy sales can affect technical feasibility and revenue models.** In many countries in Africa and in Bangladesh, mini-grid projects faced seizure or shutdown when national grid extension arrived without clear policies protecting mini-grid assets or allowing integration, causing financial losses to developers and reducing investor confidence.

Addressing investment barriers

The investment readiness support to various climate-tech startups enhanced our understanding of the capital needs of early-stage startups and the challenges they face in raising funds, especially commercial capital. Many innovators noted that funding processes tend to be slow and frequently requiring match funding once initial capital is approved, causing additional delays. Many investors also lack sufficient understanding of the technologies, revenue models and profitability timelines of climate-tech businesses.

The following learnings emerged based on our understanding of the capital needs and fundraising challenges faced by climate-tech projects/businesses, and the risks and opportunities cited by potential funders and investors.

For early-stage climate-tech startups:

- **Raise sufficient capital to focus on building the business with a runway of at least 18-24 months:** Startups should ideally secure sufficient funding to maintain a financial runway of 18 to 24 months. This duration allows them to concentrate on growing and stabilizing their business rather than being preoccupied with continuous fundraising efforts. Planning for capital needs should be done with a longer-term perspective, covering about five years, to ensure sustainable growth. This approach also provides a buffer for navigating unforeseen challenges and aligning fundraising activities with strategic business milestones effectively.

- **Avoid excessive dilution of equity early in the fundraising journey:** Diluting a high percentage of equity early may discourage potential investors. Strategic equity management—such as staging funding rounds to limit dilution to reasonable levels, efficiently managing cash burn, and exploring alternative, non-dilutive financing options—can help founders retain meaningful ownership while fuelling growth. This balance enhances the startup's ability to attract future investment and sustain momentum towards important business milestones.

- **Target investors whose investment thesis is aligned to your stage, sector, capital requirements and impact ambitions:** Alignment with investors' focus areas and values is crucial. Understanding the investor's expertise, network, and ability to provide strategic support beyond capital — such as industry connections, technical guidance, or market access — is equally important. Founders should evaluate investors' track records in climate-tech, their willingness to invest patient capital over longer timelines, and their expectations regarding milestones and returns. Alignment on impact ambitions can foster a more collaborative relationship. Startups must also consider investment terms carefully, balancing the need for sufficient funding with acceptable dilution and governance arrangements to preserve their vision and control.

- **Understand investor evaluation criteria and key success metrics**: Some of the success factors cited by investors especially for early-stage climate-tech startups, include a clear long-term vision, a resilient business model and GTM strategy, strong corporate governance, team capabilities, well-structured impact measurement systems, and proven experience in establishing local partnerships alongside cultivating a loyal customer base.

- **Tap appropriate sources and types of capital based on business needs and stage of growth**

EXAMPLES OF SOURCES OF CAPITAL FOR EARLY STAGE CLIMATE TECH STARTUPS

- **Private investors:** Angel investors, seed funds, venture capital firms, private equity companies, and corporate venture arms of large corporations provide essential funding during the early and pre-commercial stages of innovation. This financial support facilitates initial product development, pilot projects, and proof-of-concept activities. Although these investments tend to be relatively modest in size, they are crucial for advancing emerging technologies and validating concepts prior to scaling. Venture capital is typically involved in financing Series A and B funding rounds, while growth equity investments are more prevalent in the later phases of technology development.

- **Public financing:** Governments often assume a critical role in funding early-stage climate technologies and sectors that private investors consider too high-risk or strategically important. Public funding addresses financing gaps in research, development, and demonstration (RD&D) efforts, enabling innovations to progress to maturity levels that attract private sector investment. These interventions commonly take the form of grants, concessional loans, and partnerships with research organizations, thereby mitigating risks associated with emerging clean technologies and expediting their readiness for market deployment. Operating at the intersection of public and private finance, MDBs and DFIs also catalyze private sector investments in climate technologies by using blended finance tools, guarantees, and concessional finance to lower risks for private investors. By absorbing some upfront risks and providing technical assistance, they help innovators overcome local market barriers and unlock significant volumes of private capital that might otherwise remain on the sidelines.

- **Publicly traded companies finance innovation through both internal budgets and external collaborations**. Internal RD&D initiatives focus on strengthening core competencies and maintaining competitive advantage. Concurrently, partnerships with startups, academic institutions, and governmental bodies provide access to advanced low-carbon technologies while distributing associated risks. The predominant approach to funding is balance sheet financing. Some firms also raise capital for RD&D through the issuance of short-term corporate bonds, affording investors exposure to innovation projects. Issuance of equity shares also serves as a mechanism for larger firms to secure funding for deployment of next-generation technologies.

- **Accelerators and incubators can also play a vital role in funding climate-tech startups.** These programs may provide early-stage financial support that helps bridge the gap between concept and commercialization. They typically offer a combination of grant funding, equity investments, or convertible notes, alongside mentorship, technical guidance, and access to industry networks.

For investors:

- **Include technology validation and pilot results into investment due diligence for making informed investment decisions:** Technology derisking through trials on local sites with potential buyers, can complement traditional financial analysis, which may overlook commercial readiness of climate-tech ventures. This can help bring down the time taken for due diligence. These insights offer investors a clearer view of scalability, adaptability, product-market fit, technical feasibility, and deployment risk, enabling more efficient capital allocation and boosting investor confidence in the climate-tech innovation ecosystem.

- **Aggregate innovators in similar markets to create economies of scale, enhance investment attractiveness, and reduce operational costs:** Funders can collaborate by sharing due diligence assessments, allowing those who have already vetted a company to help others streamline their own evaluation processes for match funding. Such network effects and collaboration are essential for scaling emerging technologies in capital-intensive sectors like clean energy, where risk mitigation and cost control directly improve investment outcomes.

- **Tailor investment evaluation frameworks to both sector and stage of the climate businesses:** Climate-tech startups span diverse sectors, each with unique timelines, risk profiles, capital needs, and impact potential based on their sector and maturity. Distinct cost structures, adoption challenges, maturity levels, and environmental effects necessitate customized due diligence criteria and metrics.

- **Leverage investor-startup/innovator connect events to align investor capital with relevant startups.** Through mock pitches and facilitated networking, investors gain direct exposure to the startups, enhancing their understanding of commercial applications, sector trends, and capital requirements. At the same time, the startups also understand investor expectations, available pools of capital and relevant financial instruments for their specific capital requirements.

- **Enable staged or milestone-based funding:** Milestone-based funding especially for early-stage startups, enables progressive de-risking while communicating technology and market validation pathways that assure investors of scalability across successive funding rounds.

Conclusion

Focusing on de-risking early-stage climate-tech innovations both technologically and financially, fostering strategic partnerships, and embedding principles of gender equality and social inclusion, can help propel numerous climate-tech businesses and projects from concept to commercialization, addressing key challenges of affordability, accessibility, and sustainability.

Our learnings from various programs underscore the importance of tailored support to startups, encompassing technical development and technology validation, business model innovation, market engagement, and investor readiness, which collectively enable innovators to scale impactful solutions that contribute to climate mitigation and adaptation and inclusive economic growth.