CLIMATE CHANGE STRATEGIES 2020

CTCN
CLIMATE TECHNOLOGY CENTRE & NETWORK

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From ambition to action

The full deployment of technologies to reduce greenhouse gas emissions and build resilience to the impacts of climate change is vital if we are to realise the vision of the Paris Agreement.

By **Patricia Espinosa**, Executive Secretary, United Nations Framework Convention on Climate Change (UNFCCC)

The Climate Technology Centre and Network (CTCN), the implementation arm of the UNFCCC's Technology Mechanism, has been matching the technology needs of developing countries with world-class solutions since 2013.

The global expertise that countries are able to access through their national focal points for climate technology is delivering tangible results on the ground. Increasing partnership with the Green Climate Fund (GCF) is helping to unlock strategic investment, and strengthened capacity from the community to the national level to absorb and maximise the use of innovative technologies, policies and approaches is demonstrating that the Technology Mechanism of the United Nations Framework Convention on Climate Change (the Convention) is delivering on its mandate to serve the poorest and most vulnerable.

National Designated Entities (NDEs), the focal points responsible for channelling requests for technical assistance to the CTCN across 134 developing countries, are the backbone of this cooperation. They coordinate domestically across government ministries and with project proponents to ensure they are aligned with their country's Nationally Determined Contribution (NDC). Twenty-seven developed country NDEs, meanwhile, work with the CTCN to identify opportunities to support, with expertise or financial resources, needs identified through these requests.

All NDEs play an important role in raising awareness of the service offerings of the CTCN, including identifying potential organisations to join its Network of expert partners that bid on the implementation of targeted solutions. Their work spans the full scope of climate technology: from building flood models to support sustainable urban planning in Asian megacities, to designing distributed solar photovoltaic systems in Africa, to planning networks to monitor ecosystem resilience in South America, to helping vulnerable countries in the Caribbean strengthen their building codes to resist ever-strengthening hurricanes.

> **The term "climate technology" covers a broader scope than many realise... climate technologies have been deployed on an unprecedented scale around the globe**

Climate technology

The term "climate technology" covers a broader scope than many realise. In recent years, climate technologies have been deployed on an unprecedented scale around the globe. Certain renewable energy technologies are now competitive with fossil fuel options for electricity generation, and technology assessments and roadmaps developed by the CTCN and its partners help ensure that appropriate technology choices are made by governments and that enabling environments are in place to support domestic and international investment to scale-up their deployment.

Studies have also shown that investments in energy efficiency can be

Maintenance crew at the Sunny Bangchak solar farm, Thailand. The facility has a capacity of 38MW, substituting electricity derived from coal and avoiding 38,000 tonnes of CO_2 emissions per annum. © Patarapol Tularak/ADB

the most cost-effective means to reduce emissions and support sustainable economic development. These measures, such as better insulation in new buildings and upgraded standards for appliances, lower demand for electricity – delivering lower emissions while enabling existing infrastructure to be channelled towards improvements in standards of living.

That's why, for instance, the CTCN is partnering with the GCF in ten countries in Southern Africa to improve standards for appliances and transformers, just one way in which the Financial and Technology Mechanisms of the Convention are collaborating to support the climate mitigation needs of developing countries.

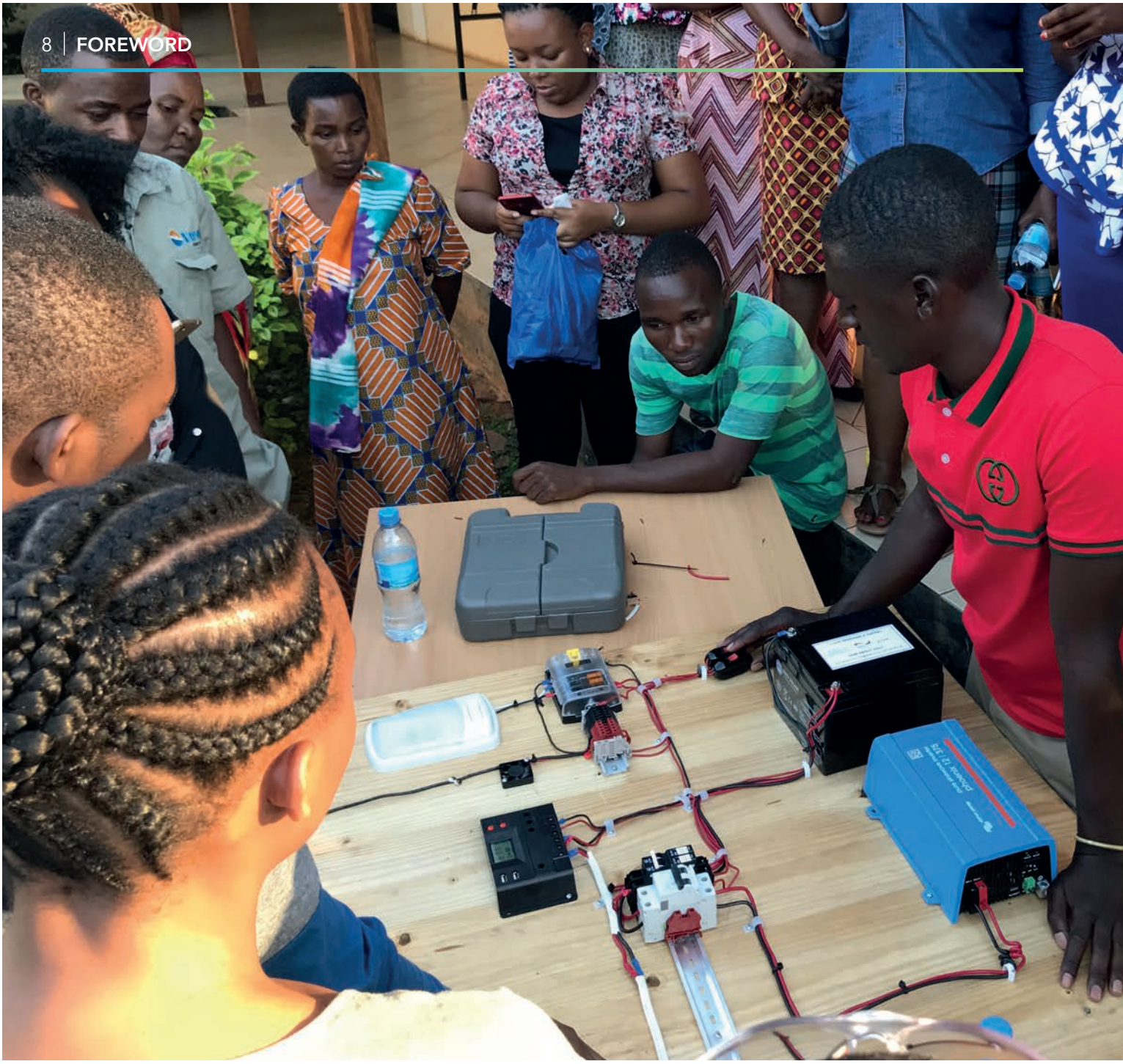
The deployment of climate technologies for adaptation is arguably even more important. Developing countries require the full support of the global community to strengthen their resilience to changing rainfall patterns and rising seas, enhance agricultural production and food security, and support the efforts of governments to meet the needs of their populations.

The requests made of the CTCN for adaptation are balanced across agriculture and forestry, infrastructure and urban planning, coastal protection and early warning systems, and water sustainability. Its partners are active in developing coastal adaptation strategies, adaptation monitoring systems, sharing agricultural best practices and working with cities to inform more resilient development strategies.

This work can be shared and replicated within and across regions, including in partnership with regional development banks and the Adaptation Fund to increase its impact.

The scale and ambition of these actions, however, still fall short of where we need to be. The IPCC *Special Report on 1.5C* states that global emissions must be halved by 2030 and net-zero by 2050. We must collectively raise our ambition if we are to rise to the level of the challenge before us. We need tomorrow's technologies and innovation, but while also scaling up the deployment of those in existence today. The stories in this publication provide a window into the good work being done under the umbrella of the Convention in partnership with civil society and the private sector to support the actions articulated in country NDCs, and support them to raise their level of ambition as we approach 2020.

Let us meet this challenge, together. ■



Enabling the Paris Agreement

The Climate Technology Centre and Network (CTCN) connects countries with the know-how, technology and finance to achieve their climate goals.

By **Rose Mwebaza**, Director, CTCN

Technology transfer, along with finance and capacity building, is recognised as one of the pillars of implementation for the international climate process coordinated by the UN Framework Convention on Climate Change (UNFCCC).

It also supports the development objectives enshrined in the Sustainable Development Goals (SDGs), and is a key component of the work being undertaken by countries to realise the vision of their Nationally Determined Contributions (NDCs) in support of the Paris Agreement and the fight against climate change.

Future solar energy technicians being trained in Tanzania. © CTCN

The UN Secretary-General has been unequivocal that the objective of achieving carbon neutrality in 2050 is possible, and the Intergovernmental Panel on Climate Change has established that staying within 1.5°C of temperature rise by the end of the century is not out of reach.

To do so, however, is to recognise that all actions are interlinked, and that to deliver on Agenda 2030 we must mobilise the international community as a whole and address climate change in a systemic manner. Most important of all is the urgency with which we rise to meet the challenge before us.

Matching needs with expertise

The CTCN is an institution created by Parties to the UNFCCC in 2010 to stimulate technology cooperation and enhance the development and transfer of climate technologies.

Since beginning its operations in 2013, it has undertaken projects in 93 countries responding to over 170 technical assistance requests intended to address specific country needs identified by developing countries. It has trained more than 2,500 officials and concluded in excess of 100 projects anticipated to leverage $900 million and reduce nearly 120 megatonnes of greenhouse gas emissions over the next ten years. This has all been delivered for approximately $50 million through a network of more than 500 expert implementing partners in less than six years.

The niche of the CTCN is unique: in line with the guidance of the Addis Ababa Action Agenda that 60-70 per cent of funding to deliver on the SDGs and Paris Agreement must originate with the private sector, the CTCN matches global expertise across the full spectrum of climate technologies to deliver the transformational solutions required by the developing world.

CTCN's implementing partners deliver targeted results that empower project proponents and recipients. The technology feasibility studies and prioritisation assessments, decision-making tools and policy expertise that result from these interventions support the development of, for instance, new regulatory and investment frameworks, monitoring systems, efficiency standards and climate-resilient urban planning.

Scaling-up solutions

What makes these projects 'transformational' is their potential to alter the trajectory from business-as-usual. Because countries prioritise partnership with the CTCN on issues with high potential for replication and scalability, the outputs of CTCN support can transform the approaches adopted by economic sectors, municipalities and national governments.

In cases where national climate change priorities align across countries, the CTCN provides regional assistance to amplify the impact that countries can achieve.

> **CTCN matches global expertise across the full spectrum of climate technologies to deliver the transformational solutions required by the developing world**

The CTCN partners with the Financial Mechanism of the UNFCCC – the Global Environment Facility and Green Climate Fund – through their country focal points to pilot innovative approaches and scale-up project ideas that build resilience and reduce greenhouse gas emissions. By working with these and other institutions, such as the European Bank for Reconstruction and Development and the Adaptation Fund, the CTCN is able to offer climate finance providers investible technology projects.

The services of the CTCN are channelled through national focal points for climate technology who ensure that the actions to be undertaken align with national climate priorities. These Nationally Designated Entities (NDEs) act as project originators, filling the project pipeline of the CTCN with project opportunities that meet developing country needs for climate technology and contribute to NDC implementation.

In addition to providing vetted project ideas to development finance institutions, the CTCN's 131 developing country NDEs are well-positioned to identify key strategic sectors and areas that would benefit from coordination among international climate partnerships, donors and other project investors.

Implementing resilience practices in the Cook Islands. © CTCN

Confronting and properly addressing climate change will take constant innovation, leadership, courage and creativity at every level

Building capacity

CTCN interventions also help to build capacity in host countries to adopt and use climate technology, both through engaging local partners to ensure the suitability of the response to the national situation of the country and by hosting training and matchmaking workshops.

These capacity-building efforts extend beyond NDEs to include local stakeholders, Network members, other government officials and climate-focused institutions with an interest in applying the technology in question and ensure that appropriate institutional and practical knowledge is retained.

To generate greater awareness about relevant technologies and methods for building enabling environments to support technology innovation, investment and deployment, the CTCN offers the world's largest online resource for climate technology information, www.ctc-n.org.

The CTCN is increasingly working with two specific constituencies to strengthen the effectiveness of its activities: women and youth.

Technology transfer and uptake can only be scaled up by ensuring that both women and men have access to relevant decision-making, finance and technical skills development. In this way, technology outcomes are more likely to be successful and sustainable for the communities they serve.

The CTCN has been collaborating with women's organisations since its inception to identify and highlight best practices, provide capacity building and ensure gender mainstreaming in the delivery of its technical assistance services.

In 2019, the CTCN finalised its Gender Policy and Action Plan to guide operations and gender mainstreaming of its core service areas. The CTCN gender focal point works proactively with strategic partners to promote internal and external capacity building on gender, and has introduced procedures, tools and methods for mainstreaming gender into CTCN core service areas.

The CTCN also co-hosts a Gender-Just Climate Solutions awards programme highlighting innovative climate change solutions from around the world that feature strong gender integration. Winners receive intensive mentoring on up-scaling their initiatives through advocacy and relationship building, training on access to finance, and networking opportunities with the CTCN and its partners.

Young people, meanwhile, can be a force for development as well as drivers of technological innovation. They tend to be among the first to embrace new ideas and frequently recognise the global and local dynamics of development. At the same time, they are increasingly aware of the impacts of actions that may jeopardise progress towards Agenda 2030 and the Paris Agreement.

Leveraging the collective voices of young people involves effectively engaging stakeholders including universities, professional societies, academies of science and engineering, and youth-focused private and public organisations.

The CTCN is deepening its engagement with the youth constituency of the UNFCCC, and looks forward to developing an approach that supports their specific needs, including for capacity building and education, youth-centric networking and information-sharing, and support for the development and diffusion of innovative approaches and best practice to be shared among developing-country partners and other branches of the UNFCCC.

Delivering on the promise

Confronting and properly addressing climate change will take constant innovation, leadership, courage and creativity at every level of our society. Even as advances in clean technologies make low-carbon pathways economically and technically feasible, international collaboration remains vital to enable developing countries to make this transition. The CTCN will continue its mission to deliver targeted technology interventions to unlock transformational climate action in developing countries and emerging economies.

I look forward to working with you to bring these solutions to life. ■

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Power of the Network

The network aspect of the Climate Technology Centre and Network (CTCN) endows it with vast capability. It also amplifies the potential impact of its individual members.

By **Orly Jacob**, Chair, Advisory Board, CTCN

The Climate Technology Centre and Network (CTCN) was created by Parties to the United Nations Framework Convention on Climate Change in December 2010. The CTCN accelerates action on climate change by leveraging the expertise of civil society and the private sector to meet the needs of developing countries for climate technology.

The "N" in CTCN

Since it began operations in 2013, the CTCN has built a Network of 500 member organisations from around the world. These members are drawn from research and academic institutions; non-governmental, intergovernmental, not-for-profit and public-sector organisations; and the private sector.

Member organisations bid for the opportunity to lead projects in response to technical assistance requests from developing countries. These projects accelerate the adoption of technologies to reduce emissions and build resilience to the impacts of climate change, ultimately leading to enhanced national capacity. In turn, this creates opportunities for more ambitious national climate objectives, as well as for Network members to demonstrate their expertise.

To date the CTCN has received nearly 250 technical assistance requests.

Why a Network?

Network members are fundamental to the operations of the CTCN, which acts to build capacity, share information and deliver tailored solutions that directly respond to the needs of developing countries. The requests that are channelled to the CTCN address needs that are both specific to the unique conditions of each country, and scalable across neighbouring nations with similar circumstances.

Members possess expertise across the full scale of adaptation and mitigation technologies and assist in the delivery of everything from technology roadmaps to the formulation of geothermal policy and regulatory frameworks to developing climate-smart agriculture manuals.

Members of the Network also contribute knowledge products (including case studies, technology assessments, and information on new technologies and approaches) to the largest online climate technology portal on the internet, ctc-n.org.

For example, detailed descriptions of more than 100 gender-just climate initiatives were recently shared by the UNFCCC women and gender constituency, and Network members have contributed approximately 80 webinars that are accessible to the public. The website serves as a clearinghouse for information on all of the technical assistance interventions undertaken by the CTCN and its partners. It also lends profile to the work its members are doing in support of developing-country climate priorities.

Who's in the Network?

Network members are drawn fairly equally from the Global North and South and are able to bid on opportunities to implement technical assistance worldwide through a bidding process managed by UNIDO. To help ensure the cultural, linguistic and technical suitability of the proposed solution, and that local capacity is retained if the lead implementer is from a different region, project bids must include a local partner based in the recipient country to help liaise with the proponent and national technology focal point.

Most Network members are micro-, small- or medium-sized enterprises (MSMEs), and experience has shown that

> **CTCN has built a Network of 500 member organisations from around the world**

MSMEs are best suited to bid on and implement the size of projects requested of the CTCN (generally US$75-200K). They are also most able to benefit from the opportunities created by working with the CTCN, including opening doors to new markets, and creating local partnerships and networking opportunities.

These projects present sound, vetted opportunities to collaborate with the United Nations and contribute to the achievement of the Sustainable Development Goals and the Paris Agreement. The bidding process is managed by UNIDO and the successful bidders work directly with national governments and the CTCN to ensure smooth implementation.

Research and academic institutions are particularly valuable contributors to these types of partnerships. They bring research expertise and an understanding of innovation cycles, which supports innovation needs assessments and the development of national systems to stimulate technology innovation.

In addition, these institutions strengthen the Network's ability to respond

Personnel from the Green Technology Center (GTC) of Korea, a Climate Technology Centre and Network member, working on home water desalinisation systems and flood-resistant housing models in the coastal areas of Bangladesh. © CTCN

to developing-country needs with strong modelling and forecasting capacity. By working with private-sector organisations, they can also help create opportunities to apply their research capacity to commercialise early-stage climate technology solutions for adaptation and mitigation.

Additionally, research and academic institutions possess deep experience collaborating across borders and finding common purpose among diverse communities – skills necessary to accelerate climate action.

Why join?

For public-sector agencies and governments, partnering with the CTCN is a low-risk, low-cost means of leveraging technologies and approaches developed in-house with countries in need. The CTCN essentially serves as project originator, operating through a series of national focal points for climate technology that ensure all initiatives are aligned with, and contribute to, Nationally Determined Contributions. Sharing and replicating best practices across countries and regions can help spread the implementation of proven solutions while fostering innovation in international development partnerships, supporting foreign policy objectives and crowding-in additional financing from regional development finance institutions. Since many of the requests received by the CTCN are for early-stage technical support and policy-focused interventions, partnering with the CTCN also helps to create the enabling environments necessary to secure needed private-sector investment.

Network members are invited to participate in regional CTCN events alongside government representatives and other climate focal points, including the Global Environment Facility and Green Climate Fund. The CTCN continues to strengthen intra-Network cooperation, forging partnerships that promote North-South, South-South and triangular cooperation for the benefit of recipient countries and implementing partners alike. It also organises matchmaking events based on its analysis of regional needs and invites organisations with relevant expertise to participate alongside development finance experts such as the Private Financing Advisory Network (PFAN) and government climate officials to realise opportunities with benefits for all.

Perhaps most fundamentally, the implementing institutions that are part of the CTCN Network are the delivery mechanism for the current and future technologies, and the capacity to absorb and implement them, that lie at the heart of the Paris Agreement.

Technology and capacity, supported by finance, are the means of implementation that will enable countries to take more ambitious strides towards decarbonising their economies, protecting human rights, supporting economic growth, and building resilience to the impacts of climate change.

It is often said that climate change is a global challenge; we must meet this challenge through the full deployment of all the tools at our disposal, across every sector, in every country around the world. The expertise of the Network and its ability to deliver world-class, customised solutions to developing countries is a vital component of this solution. I invite you to join us. ■

Pathways to 1.5°C warming

Current efforts to tackle climate change fall well short of what's needed to limit temperature rise to manageable levels this century. A step change would be needed to get on track.

By **Jim Skea**, Professor of Sustainable Energy, Imperial College London and Co-Chair, IPCC Working Group III (Mitigation of Climate Change)

Three decades after the Intergovernmental Panel on Climate Change (IPCC) was established and preparations started for the UN Framework Convention on Climate Change (UNFCCC), there are encouraging signs that action to address climate change is finally picking up pace. The evidence comes from right across society.

Diplomatically, the 2015 Paris Agreement set governments the challenge of stating their ambitions to tackle climate change, measuring the collective impact of their actions through a regular global stocktake, and encouraging them to ratchet up their aspirations. Countries have started to respond by setting 'net zero' targets, which balance emissions and sinks of greenhouse gases.

This is achieved, for example, by setting sectoral targets for renewable energy, phasing out petrol and diesel cars, and increasing rates of afforestation. Economically, many companies and sectors, notably the financial sector, have bought into the climate agenda and are taking steps to change the direction of their businesses (see panel on page 16). There is also unprecedented awareness of climate change in civil society, reinforced by the activities of groups such as Extinction Rebellion and the huge global impact of Greta Thunberg and her colleagues. This all culminated in the UN Climate Action Summit in New York in September 2019.

The IPCC has helped to maintain the global focus on climate change by producing three influential Special Reports within a year: on *Global Warming of 1.5°C*, *Climate Change and Land* and *The Ocean and Cryosphere in a Changing Climate*. Each of these has warned of the serious consequences of higher levels of warming and has flagged that climate impacts are already observable – a fact that many communities can attest to through their direct experience of unusual seasonal weather, more frequent and intense storms, and wildfires.

In spite of emerging action, the news is not all good. The IPCC *Special Report on Global Warming of 1.5°C* and the regular UN Environment Programme *Emissions Gap* reports show unequivocally that the pledges currently made by governments do not set the world on a path to meeting the Paris Agreement mitigation aim of "holding the increase in the global average temperature to well below 2°C above pre-industrial levels". As the Paris Agreement also obliges countries to "pursue efforts to limit the temperature increase to 1.5°C", the implied gap between aspiration and planned action is even wider.

It is clear from the IPCC report on *Global Warming of 1.5°C* that limiting temperature rise to 1.5°C would require rapid, far-reaching and unprecedented changes in all systems, including energy, land, urban and industrial systems. Coal use must fall by at least three quarters by 2050 in emission pathways compatible with 1.5°C warming, accompanied by significant declines in oil use and, in most cases, the use of natural gas.

The share of renewables in the energy mix would need to grow rapidly. Changes in energy supply would need to be accompanied by large-scale investments in energy efficiency. We would also need to see the electrification of energy demand to take advantage of zero-carbon renewable electricity and, possibly, changes in our patterns of consumption, including our dietary choices.

If we do not make a prompt start with these system changes, we may need to rely on the large-scale removal of carbon dioxide from the atmosphere in the latter part of the 21st century if we are to keep global warming to well below 2°C.

This highlights a wider set of challenges. Whether through the IPCC or UNFCCC, countries have emphasised that climate action is not to be pursued in isolation. It needs to be undertaken "in the context of sustainable development and efforts to eradicate poverty", to quote from the full title of the IPCC Special Report on *Global Warming of 1.5°C*.

> **Whether through the IPCC or UNFCCC, countries have emphasised that climate action is not to be pursued in isolation**

Large-scale conversion of land to undertake climate mitigation measures at the scale of several millions of km² globally – such as for afforestation, biomass for energy or biochar – carries its own risks

Steam evaporates from the Muara Laboh Geothermal Power Project in Indonesia. CTCN is currently assisting six African countries – Djibouti, Ethiopia, Kenya, Tanzania, Uganda and Rwanda – develop geothermal power in the Great Rift Valley. © Gerhard Joren/ADB

in terms of food security, biodiversity and ecosystem services. However, such measures could deliver against a wide range of goals relating to climate mitigation, adaptation and sustainable development if they are implemented at appropriate scales using best practices supported by suitable governance mechanisms in well-managed landscape systems.

There are also many land-based mitigation options that do not require conversion of land, such as improved management of cropland and grazing lands, improved and sustainable forest management, and increased soil organic carbon content. The land sector can contribute substantially to climate change mitigation, but the aim of the Paris Agreement cannot be achieved though land alone. Major changes in all other systems would be required.

The land example highlights the wider importance of taking all climate action in the broader context of sustainable development. Alongside the adoption of the Paris Agreement, the UN has adopted the 17 Sustainable Development Goals (SDGs) for 2030. Scientists are increasingly using these to assess the wider implications of climate action and the interactions between climate mitigation, adaptation and sustainable development.

The positive message is that many specific actions, especially those relating to consumption and energy demand, can contribute positively to the SDGs. Most

CLIMATE ACTION 100+

Investors taking the lead

Climate Action 100+ is a five-year investor initiative to ensure the world's largest corporate greenhouse gas emitters take necessary action on climate change.

More than 370 investors with over $35 trillion in assets collectively under management are engaging companies on improving governance, curbing emissions and strengthening climate-related financial disclosures.

The companies include 100 'systemically important emitters', accounting for two-thirds of annual global industrial emissions, alongside more than 60 others with significant opportunity to drive the clean energy transition.

measures relating to energy supply and land management can also make positive contributions, though some, as identified above, need careful and measured implementation.

The required "rapid, far-reaching and unprecedented changes in all systems" described in the *Global Warming of 1.5°C* report are not without socio-economic challenges. The Polish Presidency of the 24th Conference of the Parties (COP) of the UNFCCC in December 2018 highlighted the importance of a just transition to gain social approval for these unprecedented changes. Unless managed well, a rapid transition could have significant negative repercussions for some industries and some communities that have until now been reliant on high carbon production.

The just transition principle aligns well with SDG 8, which refers to decent work and economic growth. Attention to high-quality jobs, skills and retraining, and processes which engage communities and workforces in a well-planned and inclusive transition will be vital in securing climate ambitions.

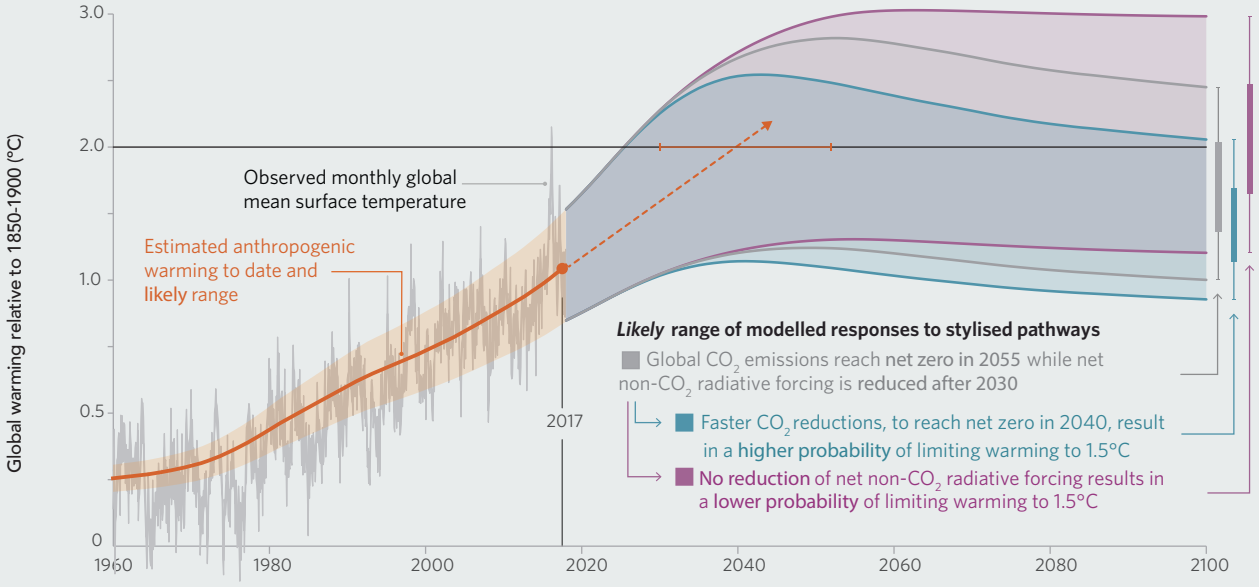
Where we are in terms of climate action can be summarised as follows. Our ambitions in terms of moving away from business as usual are huge. There are encouraging signs that countries, regions and cities are stepping up their action. But we are still a long way from where we need to be. UNFCCC COP25 hosted by Chile in Madrid in December 2019 provides the next major opportunity for governments to demonstrate their commitment. There are some obvious steps to be taken. Progressing the Paris 'rulebook' by establishing means by which countries can share their climate ambition (through 'internationally transferred mitigation outcomes') is vital.

The next big test will come in 2020 when countries are urged to submit enhanced pledges aimed at meeting the Paris goals. At this point it may be clearer whether we are indeed on the right path. ■

This article was written in a personal capacity.

CUMULATIVE EMISSIONS OF CO_2 AND FUTURE EMISSIONS OF OTHER GHGs WILL DETERMINE THE CHANCES OF LIMITING WARMING TO 1.5°C

Observed global temperature change and projected outcomes in response to different emission reduction scenarios



Source: IPCC *Special Report on Global Warming of 1.5°C*. Graphics based on the IPCC figure with minor changes to captions for clarity

Clean energy's compound benefits

As well as being a necessity for mitigating climate change, clean energy will be the core driver of sustainable development.

By **Glenn Pearce-Oroz**, Director of Policy and Programs, Sustainable Energy for All

The 50 MW wind farm at Khandke in Maharashtra State, India. © Ian Taylor/ADB

It is easy to see a global energy transition as imperative for preventing devastating climate impacts. Yet, the energy transition must accomplish different things for different places.

In developed countries, the focus of the transition will fall on how to shift existing industries and lifestyles away from carbon dependency. In developing countries, the transition must emphasise delivering new, clean energy access to help people and local economies thrive.

There are approximately 840 million people worldwide with no electricity access. Millions more have limited access because of intermittent supply or unaffordable costs. Not having at least 'Tier 3' electricity access – enough to power general lighting, phone charging and medium-power appliances, available for at least eight hours a day and three hours every evening – limits people's social and economic opportunities. These people typically live in energy-underserved communities, so reliable healthcare and education are also often out of their reach.

Meanwhile, there are roughly three billion people who do not have access to clean cooking solutions. Instead, these people rely on burning biomass, coal or kerosene, exposing themselves and their families to dangerous fumes in the process.

So, when we talk about a global energy transition, we must talk about devising

strategies that simultaneously curb emissions and deliver productive levels of sustainable energy to all, just as Sustainable Development Goal (SDG) 7 urges.

How can we do this? The list of required actions is long, but here are two themes to guide us.

Embrace energy efficiency

Major financial, political and regulatory commitments on energy efficiency are needed for the energy transition to succeed. Already touted as the 'fifth fuel', energy efficiency deserves greater prominence. It should be considered the 'first fuel' because it can deliver 40 per cent of the CO_2 reductions necessary to achieve the Paris Agreement, according to the International Energy Agency.

It is also the best way to decouple economic growth from energy demand and help us deliver the SDGs. Countries under pressure to build up their industries and infrastructure and bring new household energy access must make every unit of energy produced go further.

Combining energy efficiency measures with new clean generation will help ensure reliable access where it is most needed to support people's wellbeing.

Take healthcare as an example. A hospital or clinic of any size needs a constant supply of electricity for lighting and running equipment to keep patients safe. If there is a limited supply from its powering grid, mini-grid or off-grid solution, then this facility (and other infrastructure sharing the same power source) must be as efficient as possible. In a health centre, the building itself and medical appliances should follow strict efficiency standards to keep overall energy demand low. Hence energy efficiency implicates various businesses spurred by government policy.

Currently, only a small group of countries have Nationally Determined Contribution plans that include specific energy efficiency commitments. Governments setting firm targets would send a signal to industry to fall in line, and together they can work on developing new efficiency regulations.

Along these lines, a promising initiative called the Three Percent Club (see panel) was launched during this year's UN Climate Action Summit. It comprises 15 countries, along with corporations and institutions, committed to a 3 per cent annual global increase in energy efficiency across their economies and businesses.

These are not just high-income countries with budgetary space for energy efficiency. Several developing countries made the pledge, which highlights how energy efficiency is an investment in their overall development. Platforms like this offer a tremendous opportunity for the exchange of technical and financial support that will help the world better manage energy demand.

THREE PERCENT CLUB

Launched at the UN Climate Action Summit in New York in 2019, the Three Percent Club is a coalition of countries, businesses and international organisations that are committed to driving a 3 per cent global increase in energy efficiency each year.

To achieve this, 15 governments and 10 companies will access research by the International Energy Agency (IEA). The research shows that the right efficiency policies could deliver more than 40 per cent of the emissions cuts needed to reach the goals of the Paris Agreement, without requiring new technology.

"Energy efficiency is the one energy resource that all countries share in abundance, and it can help reduce emissions while enhancing their peoples' wellbeing," said Fatih Birol, IEA Executive Director. "Our analysis shows that we can collectively achieve much higher rates of progress, and we are delighted to see the leadership and ambition set out by these countries."

Countries involved include: Argentina, Colombia, Denmark, Estonia, Ethiopia, Ghana, Honduras, Hungary, India, Ireland, Italy, Kenya, Portugal, Senegal and the UK.

Financial, political and regulatory commitments on energy efficiency are needed for the energy transition to succeed

Finance for new, clean energy access

A rapid proliferation in electricity derived from a mix of zero-carbon, renewable energy solutions is paramount to the energy transition. Unfortunately, uptake of renewables in developing regions is languishing.

Finance is the lynchpin to providing clean, reliable electricity access worldwide. This is especially true in developing countries where public funds are scarce. The *Energizing Finance* research series developed by Sustainable Energy for All identified that in 2017 a combined $12.6 billion went towards connecting households across 20 high-impact countries with the greatest electricity access gaps.

Household connections in these countries are tricky because large segments of their populations live in rural areas without access to national grids. In most cases, these last-mile communities are best served by off-grid and mini-grid solutions because the economics of grid extensions do not add up. The good news is that these solutions are based on clean energy generation, so their widespread implementation can bring vital electricity access without causing a spike in emissions.

Unfortunately, total investment in off-grid and mini-grid solutions in the high-impact countries stood at $430 million in 2017. This is a small fraction of the $12.6 billion invested in electricity access and suggests that millions of people without grid connections are being left behind. Governments, businesses and development

Maasai of the Moduli district in northern Tanzania, where solar-powered micro-grids are providing life-saving water purification, refrigeration for food and medicines, a computer for the community, and lights for the cow and goat corrals to frighten away the hyenas. © Morgana Wingard/USAID

banks need to unlock finance for the off-grid and mini-grid sectors in the coming years so that people in hard-to-reach places can be included in the energy transition.

Innovative financing mechanisms should be designed to alleviate current barriers to investment in these sectors, such as perceived credit, liquidity and currency risks.

Development banks are particularly important to this effort and should be prioritising clean energy access – not only with their capital but with in-country technical and policy support. Their collaboration with governments can produce new financing and governance frameworks that will crowd in much-needed investment from the private sector. This is also an area of particular interest to the Climate Technology Centre and Network (CTCN), which delivers technical assistance and capacity building to countries for increased energy access.

Of course, this strategy also applies to clean cooking access. With three billion people around the world currently relying on dirty fuels, this is damaging to the environment and people's health. The Clean Cooking Alliance indicates that in many Asian and African countries, household cooking can account for as much as 60 to 80 per cent of black carbon emissions. Further, the CO_2 emissions caused by unsustainably harvested wood fuel leading to deforestation are estimated at 2 per cent of global emissions.

In terms of human impact, people cooking with dirty fuels in poorly ventilated spaces face dire health consequences, and proper ventilation just means worse air quality for surrounding areas. Clean cooking is not just an energy and climate solution, it is a public health solution.

Energizing Finance highlights how more than $4 billion in annual investment for clean cooking is needed to meet SDG 7 by 2030. But in 2017, based on available data, finance for clean cooking in 20 high-impact countries was estimated at a combined $32 million. This shortfall is shocking, considering the impact that every dollar spent on clean cooking can have on public health budgets.

Again, governments, development organisations, philanthropists, impact investors and social enterprises all need to better recognise the long-term value of aligning on clean cooking.

The sustainable energy transition is already underway. We know that shifting to clean energy will alleviate climate impacts, but the opportunity is much greater than that.

Former UN Secretary-General Ban Ki-moon called sustainable energy "the golden thread that connects economic growth, social equity and environmental sustainability". These words have universal application, so we need to ensure everyone has access to productive levels of energy, starting with the most underserved people and communities. This calls for a deepened, concerted commitment to energy efficiency and finance for clean-energy access. ■

Hydropower

A sustainable and reliable climate protector

Hydropower is a key pillar for achieving global climate protection goals – on the way towards a carbon-neutral power industry

The world is not on track to meet the international climate protection goals agreed upon under the so-called "Paris Agreement" from 2015 (UNFCCC). In fact, the overarching goal of limiting global warming to below 1.5°C is a long way off.

In order to reduce the risk of a global climate collapse, the reduction of carbon dioxide (CO_2) emissions is essential. To achieve the goal, transforming energy production to clean, renewable technologies is necessary. A transition from fossil fuels to low-carbon alternatives is urgently needed. Many governments still favour fossil fuels and shy away from effective climate protection measures. Global energy-related CO_2 emissions rose by 1.7 per cent in 2018, reaching an unprecedented level of 33.1 gigatons of CO_2.

The rise in CO_2 emissions represents the highest growth rate since 2013 and sends an alarming signal three years after the Paris Agreement. Not all industrialised and emerging countries seem to take the danger of climate change seriously enough. Thus, 169 countries introduced targets for renewable energies at the national or country level by the end of 2018.

Only very few governments have yet transposed the agreed climate targets into national law. By mid-2019, only Sweden, Norway,

France and the United Kingdom had established "zero-emission targets" in their national legislation. Countries such as Denmark, Spain, Chile and New Zealand have announced roadmaps and timelines to achieve this target as well.

How the Paris Agreement is able to pick up momentum

If the world community does not step up its commitment to the fight against climate change now, there will be no turning back. The phase-out of coal, oil and gas is possible on a global basis. The shift towards renewable energies is essential for achieving global climate targets. Hydropower plays a significant role: it has been used for centuries to generate energy and is still the world's largest source of renewable electricity today.

More than 16 per cent of the electricity generated worldwide stems from hydropower – more than all other renewable energies together. Hydropower combines an unrivalled degree of efficiency with an extremely long and reliable plant service life. In addition, hydropower offers small- and large-scale storage capacities that support flexible and dispatchable production of renewable energy, helping to stabilise other intermittent renewable sources such as solar and wind.

Pumped storage plants are the most proven, technically reliable and economical form of large-scale storage of electricity. Pumped storage accounts for 96 per cent of global energy storage capacity. Compared to batteries, pumped storage facilities have far greater output, a significantly longer typical design life of equipment and a greater number of design cycles.

Solving the storage dilemma

The worldwide potential for pumped storage power plants is enormous. The fifth continent alone, Australia, has the capacity to store up to 1,000 times more renewable energy than the country would need. Nationwide, at least 22,000 potential sites have been identified as suitable for pumped storage.

The Australian government is specifically promoting the expansion of the technology and declaring it to be one of the most important factors in implementing the country's planned turnaround in energy systems. At the beginning of 2019, the government of South Australia committed itself to providing additional funds for four new pumped hydro projects. In this way, the aim is to further increase energy production from renewable energy sources and also ensure greater grid stability.

Role model Australia

The Snowy 2.0 project is currently one of the most important hydropower and pumped storage projects in Australia. As one of the largest pumped storage basins of its kind in the world, it represents an important milestone for Australia on the road to 100 per cent electricity generation from renewable energy sources.

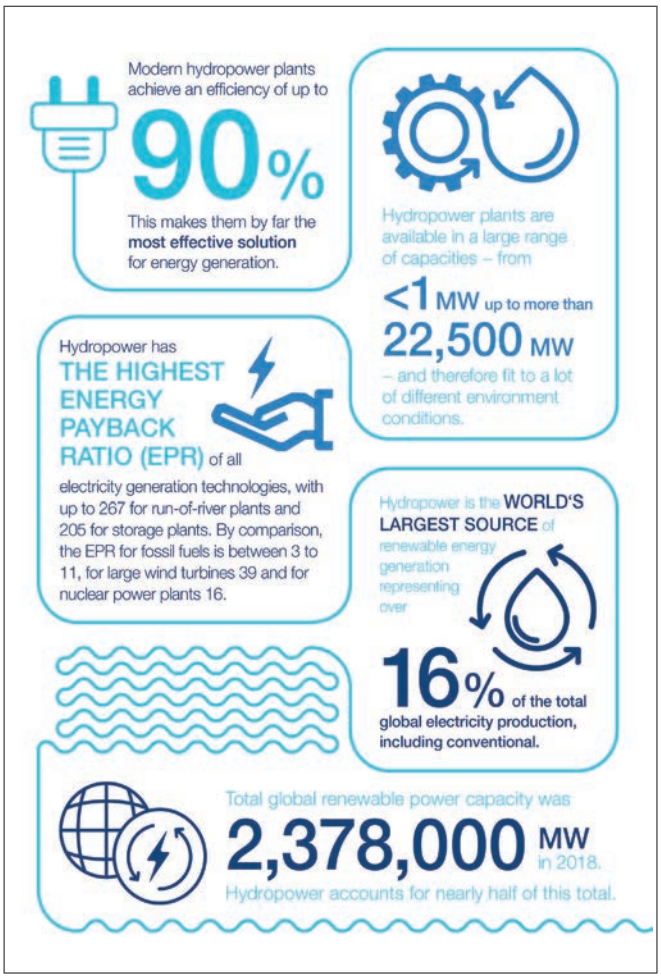
The project will connect the two existing dams of the Snowy Mountain system, Tantangara and Talbingo, through underground tunnels and an underground power plant with pumping and generating units. The underground powerhouse will contain six reversible Francis-type pump turbines. The capacity of the plant is designed for 2,000 megawatts (MW).

With more than 120 active hydropower plants having an installed capacity of almost 8,800 MW, Australia is well on track. In 2018, renewable energies accounted for 20 per cent of total electricity production for the first time. According to estimates, a share of 50 per cent is possible by 2024, and by 2032, 100 per cent would be possible. The development enables Australia to achieve the Paris climate targets earlier than scheduled in the agreement, making it a role model for other countries.

Shining examples of sustainable hydropower development

There are other countries that integrate renewable energies – and hydropower in particular – into their energy mix in an exemplary way. Iceland, for example, generates 99 per cent of its energy from renewable sources – mainly hydropower and geothermal power.

Regarding annual investment in net capacity additions, Iceland ranked fourth globally in 2018. For example, the country increased its generation capacity with the commissioning of the 100 MW Búrfell II power plant in 2018. It uses the energy that had previously flowed unused past the older Búrfell station, built in 1969, thus providing more flexibility in operation.



Plant operators are investing in forward-looking technologies in order to further optimise the maintenance and operation of the power plants

Budarhals plant, Iceland: Hydropower can make an important contribution to achieving global climate goals

In addition, the plant operators are investing in forward-looking technologies in order to further optimise the maintenance and operation of the power plants. The Budarhals plant is equipped with Voith's acoustic monitoring system for intelligent noise analysis and asset management features.

Thanks to its vast landmass and diverse geography, Canada also possesses an enormous abundance of renewable energy sources for power generation. In 2017, the country launched a nationwide dialogue on Canada's energy future. More than 380,000 citizens took part. The conclusion: experts, industry representatives and consumers advocate clean energy – including the use of hydropower. Currently, six Canadian provinces and territories generate more than 94 per cent of their electricity from renewable sources – hydropower is at the forefront.

Reventazón, the largest hydropower project in Central America, has an installed capacity of 305.5 MW and supplies more than half a million households with electricity. Since it came into operation, the project has led Costa Rica to achieve a target of generating 100 per cent of its electricity from renewable energy sources. This makes the hydropower plant an important component of the green revolution in Costa Rica and underscores the government's plan to abandon fossil fuels by 2021.

About the Voith Group

The Voith Group is a global technology company. With its broad portfolio of systems, products, services and digital applications, Voith sets standards in the markets of energy, oil & gas, paper, raw materials and transport & automotive. Founded in 1867, the company today has more than 19,000 employees, sales of €4.2 billion and locations in over 60 countries worldwide and is thus one of the larger family-owned companies in Europe.

The Group Division Voith Hydro is part of the Voith Group and a leading full-line supplier as well as trusted partner for equipping hydropower plants. Voith develops customised, long-term solutions and services for large and small hydro plants all over the world. Its portfolio of products and services covers the entire life cycle and all major components for large and small hydro plants, from generators, turbines, pumps and automation systems, right through to spare parts, maintenance and training services, and digital solutions for intelligent hydropower.

VOITH

CTCN thanks Voith for its generous support for this publication

Preparing and transporting sand-filled geo bags, which will be used to reinforce river banks in Assam, India. The geography of Asia and the Pacific makes the region highly susceptible to rising sea levels and extreme weather. © Rakesh Sahai/ADB

Forward-thinking adaptation

Innovative adaptation projects offer hope for climate-vulnerable communities around the world – but need urgent political and financial investment before it's too late.

By **Srilata Kammila**, Head of Climate Change Adaptation, United Nations Development Programme (UNDP)

Climate change is no longer a threat in the distant future. It is here now and we need to adapt to the challenges it brings.

Unprecedented wildfires in California, crippling droughts across the Horn of Africa, deadly storms and floods in the Bahamas and Japan – recent headlines give us a taste of what climate change has in store for humanity.

However, not all countries are affected by climate change at the same scale. Nations in less developed regions in the Global South are not only hit first but also hardest by the impacts of climate change.

Asia and the Pacific is the most disaster-prone region in the world. Its geography makes it highly susceptible to rising sea levels and weather extremes. With some communities scattered across archipelagos, scaling up climate action can be problematic.

Africa is another region at its tipping point. Changing weather patterns pose an existential threat to the poverty-stricken region. Water shortages could significantly reduce crop yields and put large parts of the population at risk of undernourishment. The Arab states are not faring much better. In addition to

widespread conflict and displacement, the Arab region has the highest water insecurity and dependency on food imports on the planet. Climate change is exacerbating these challenges.

With the most vulnerable people bearing the brunt, climate change has the potential to derail decades of hard-won human development. Ultimately, climate change could drive an additional 100 million people into poverty by 2030.

How can we tackle the daunting task of protecting people and planet in the face of erratic weather patterns and rising sea levels? The tools and technologies already exist. We need immediate and urgent action to mainstream, scale up and accelerate climate change adaptation across the globe. Partnerships are critical to deliver climate action on the ground – in particular, ensuring access to technologies and practices for the most vulnerable to adapt to the changing climate. Partners, like the Climate Technology Centre and Network (CTCN), are important in facilitating technology solutions and capacities for countries to shift to low-carbon, climate-resilient pathways.

Breaking down silos

Climate change impacts every aspect of our lives. It threatens our food security, water supply, health, economy and overall safety. As a result, we cannot tackle it by taking a siloed approach.

Reducing carbon emissions, adapting to climate change impacts and boosting sustainable development must be delivered together if we're to achieve our vision of a resilient, sustainable and low-carbon future.

A project aimed at mitigating climate change is a lost investment if it doesn't consider adaptation measures to current and future climate stresses as well as the effects climate change has on human development.

On the other hand, a project helping communities cope with climate change impacts may actually increase carbon emissions if mitigation principles are not taken into account.

Take, for example, a UNDP-supported project in Mali funded by the Global Environment Facility (GEF). Shorter rainy seasons and prolonged droughts have led to declines in crop yields, putting pressure on women to support their families with alternative incomes.

Training women in sustainable agriculture and land management, constructing a solar-powered well, and introducing a mill running on solar energy not only improved food security in the community, but also contributed to additional income for the women.

The integrated project approach resulted in benefits reaching across the Sustainable Development Goals, from poverty reduction and gender equality to clean energy and climate action. It's a win-win-win across mitigation, adaptation and sustainable development.

Letting countries lead

Countries and communities need to be at the heart of adaptation programmes and projects to ensure their success and sustainability. By involving governments, communities and other relevant stakeholders in all stages of adaptation planning, from risk assessment to project design to implementation, we can provide tailored solutions to communities' individual challenges and boost community ownership.

In Sri Lanka, community consultations and involvement have led to a unique approach that is bringing water to the country's dry zone. A UNDP-supported project financed by the Green Climate Fund (GCF) is helping farmers to cope with the adverse effects of climate change by reviving an ancient cascade system of water tanks.

Collecting and redistributing every single drop of rain the land receives for drinking water and irrigation makes a huge difference for the local population. Paired with trainings on climate-smart farming and improvements to the hydrological forecasting system, the community is better prepared for the next drought.

CTCN has an adaptation project in Sri Lanka, where it is assisting in establishing Kurunegala as a climate-smart city. Most urban systems in Kurunegala, which is located in the country's North Western Province, are vulnerable to the impacts of climate change and this project will help to enhance climate resilience and low-carbon pathways for the city.

> **Protecting our people and planet from the devastating effects of climate change requires a new kind of preparedness**

Boosting private-sector investment

According to UN Environment's 2016 *Adaptation Finance Gap Report*, adapting to climate change risks will cost the world between $140 and $300 billion per year by 2030. Currently, adaptation finance is estimated at about $22 billion per year.

Bridging this massive funding gap will require significant private-sector investment and engagement. But how can we unlock it? There are many reasons for the current lack of private investment – from insufficient knowledge about climate risks to limited technical capacity to regulatory obstacles.

Eliminating existing barriers for the private sector means assessing climate risks, building local competence, designing robust policies and regulations, creating markets for local goods and services, introducing partnerships and collaborations, and de-risking investments.

In the Maldives, a GEF-funded project helped to do just that. With an average height of less than two metres above sea level, the Maldives is one of the most vulnerable countries to climate change.

As tourism is the main driver of the island nation's economy, the UNDP-supported project helped to conduct risk assessments and integrate climate change adaptation into policy and planning instruments for the tourism sector. With the nation now better prepared for climate-related shocks, the initiative boosted new investment partnerships between the Government of Maldives and tourism resorts.

Flood refugees queue for treatment at a mobile clinic in Southern Malawi. The country is suffering more intense and frequent weather extremes. © Arjan van de Merwe/UNDP

Scaling up innovation

Innovation is key to cope with climate change impacts. At a local level, communities are responding to climate stresses in innovative ways. Replicating successful solutions in other parts of a country or region can save valuable time and money. By setting up pilot projects and carefully monitoring their results, insights and best practices can be fed into policy processes, helping to scale up successful approaches.

In Malawi, a series of UNDP-supported interventions showcase scaled-up innovation. The country faces more intense and frequent weather extremes such as floods, droughts and storms. Early-warning systems for extreme weather events can prevent weather-related deaths, improve local food security and protect people's health.

After the country's National Adaptation Plan of Action provided the framework to develop early-warning systems, a successful pilot in seven disaster-prone districts helped to feed disaster risk reduction insights into policies and planning processes at all levels of government. A GCF-financed project supported by UNDP is now building upon this foundation to expand its reach nationwide, with about three million people benefiting from it.

Working towards climate-resilient societies

Protecting our people and planet from the devastating effects of climate change requires a new kind of preparedness. We need to assess and identify climate risks, build technical, financial and institutional capacities, create climate-resilient policies and economies, and integrate climate action with sustainable development.

Making this a reality requires large amounts of funding from the public and private sector. The longer we wait to scale up these investments, the more expensive climate action will get.

Since 2008, UNDP has mobilised $1.2 billion from vertical funds and bilateral donors and leveraged an additional $3.1 billion from public and private partners via co-financing to implement 220 adaptation projects across 93 countries. These projects have directly increased the resilience of the lives and livelihoods of more than 80 million people. By supporting the national adaptation planning process, UNDP has helped over 75 countries integrate climate risks into policies, strategies, plans and budgets at national and local level.

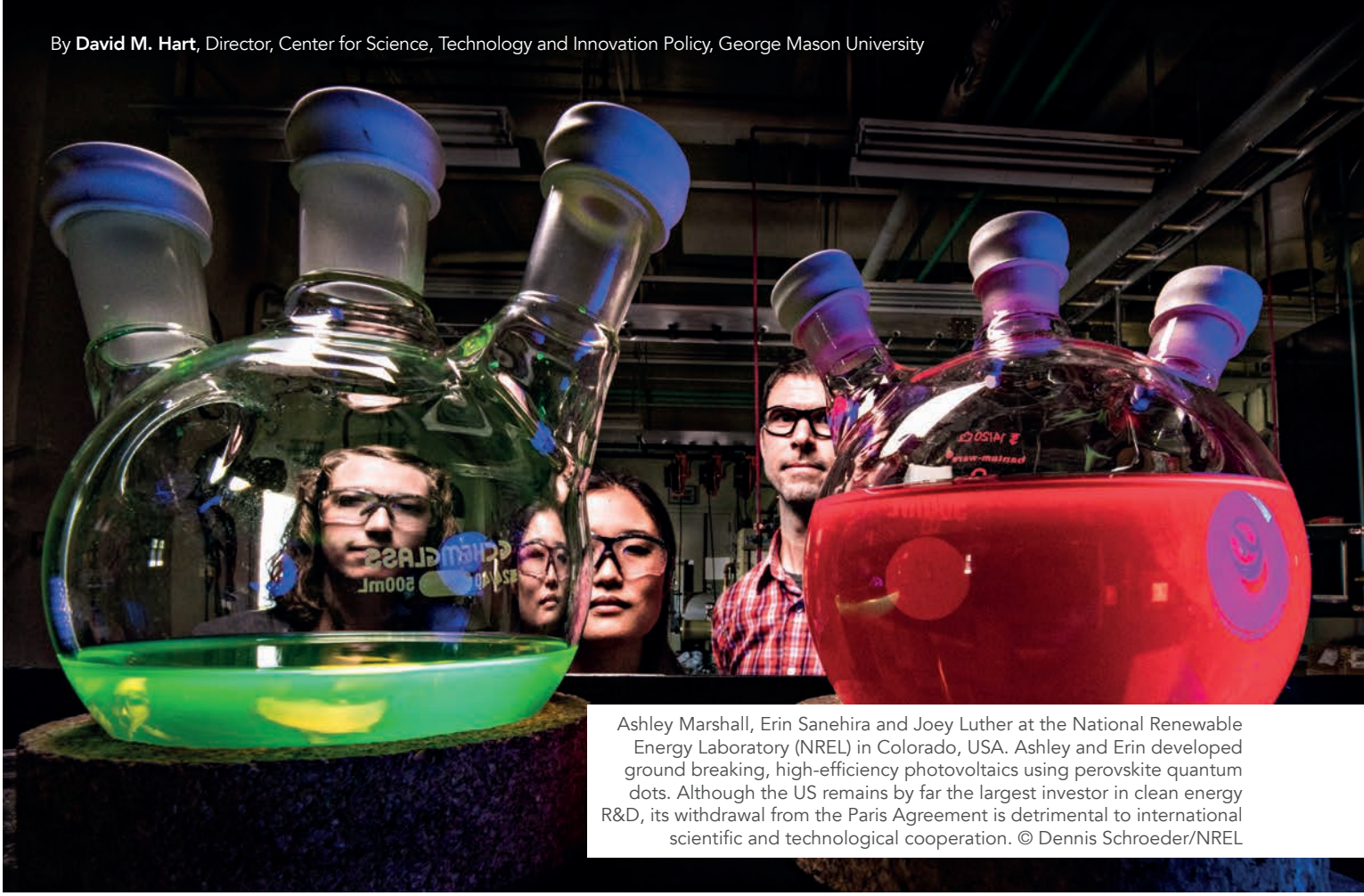
Going forward, we have big plans to increase global ambition. With our 'Climate Promise', we aim to support 100 countries in enhancing their national climate pledges under the Paris Agreement – the Nationally Determined Contributions – by 2020, focusing on both mitigation and adaptation.

By 2022, we will help over 150 million people adapt to climate change. By doing so, we will help them benefit from increased safety, wellbeing, food and water security, resilient livelihoods and enhanced ecosystem services. ■

Energy innovation: the forgotten side of Paris

Rapid innovation in clean energy technologies is essential to meet the 1.5°C target. Despite bold commitments from nations, progress is well behind what's needed.

By **David M. Hart**, Director, Center for Science, Technology and Innovation Policy, George Mason University



Ashley Marshall, Erin Sanehira and Joey Luther at the National Renewable Energy Laboratory (NREL) in Colorado, USA. Ashley and Erin developed ground breaking, high-efficiency photovoltaics using perovskite quantum dots. Although the US remains by far the largest investor in clean energy R&D, its withdrawal from the Paris Agreement is detrimental to international scientific and technological cooperation. © Dennis Schroeder/NREL

When the Paris Climate Agreement was signed in 2015, many of the world's major powers also affixed their signatures to another agreement called Mission Innovation. By doing so, they committed themselves to accelerate innovation in technologies that will lead to rapid reductions in greenhouse gas emissions.

Tragically, this other Paris agreement has largely been forgotten. Yet, unless its terms are fulfilled, and indeed the signatory nations build ambition beyond it, the main Paris Agreement is doomed to failure.

Here's why rapid innovation is so important. First, no realistic solutions have been developed to eliminate emissions from a variety of major sources. These include cement, iron and steel production in the industrial sector (three billion tons or about 6 per cent of global emissions annually), shipping and aviation in the transportation sector (two billion tons or 4 per cent), and many forms of agriculture (which totals five billion tons or about 10 per cent).

Second, while zero-emissions options exist for other major sources, they are likely to remain too expensive or impractical to fully displace entrenched incumbent high-emissions technologies without substantial further innovation. This is particularly the case for developing-

country applications. In the power sector, for instance, an estimated one third of all electricity generation will need to come from zero-carbon resources other than wind and solar power, which generate power intermittently. Advanced nuclear and bioenergy with carbon capture and storage (BECCS) is among the 'firm' power technologies that are in need of intensive further research, development and demonstration (RD&D) to fill this gap. Also ripe for more RD&D are long-duration energy storage systems that can back up intermittent wind and solar resources.

Third, it is important to build resilience against the prospect that global efforts to reduce emissions will fall short of the targets set in Paris. In such a circumstance, technologies to remove carbon directly from the atmosphere may need to be deployed on a large scale to get the world back on track. Although there are a diverse range of potential options for carbon removal, most of these technologies are still in their infancy.

Increasing urgency

The need for energy innovation has become ever more urgent. Unfortunately, the response to this challenge has not been encouraging. To be sure, major progress has been made in important technologies like solar panels, wind turbines and lithium-ion batteries, which has enabled massive cost reductions and rapid diffusion. Overall, though, patent applications for climate change mitigation technologies, a useful predictor of future innovation, have been in decline globally since 2011. This decline was consistent across all the major nations except China. It has been most pronounced in renewable energy, carbon capture and smart grid technologies.

An important factor in this decline has undoubtedly been lower oil and natural gas prices over the last 10 years. After rising steadily through most of 2000s to a peak of over $100 per barrel, the price of crude oil dropped abruptly in the wake of the global recession. Cheaper prices for high-carbon energy resources weaken the incentive for low-carbon energy innovation, because they make competition in end-use markets much more challenging.

Public policymakers could level the playing field by imposing a carbon price (or raising fuel taxes). However, relatively few nations have chosen to do so. In fact, when the countries participating in Mission Innovation are taken as a whole, the effective carbon price is negative – they are subsidising fossil fuels, creating further barriers to low-carbon energy innovation.

The reluctance of governments to raise energy prices significantly is understandable, considering the essential role that energy plays in everyone's lives. If innovation could narrow the price gap between high and low-carbon technologies, a modest, more politically palatable carbon price would encourage a more rapid transfer to cleaner technologies.

To narrow this gap, governments will have to provide a strong technology push. Mission Innovation committed its 24 signatory nations, along with the European Union, to do exactly that. The agreement pledges a doubling of public clean energy RD&D spending over a five-year period, as well as cooperation to tackle the most pressing technical issues.

But too few nations are making good on these promises. Rather than being on track to double by 2020 or 2021, clean energy RD&D investments made by all Mission Innovation countries combined rose only 13 per cent between 2015 and 2018. Across much of Europe – including France, Italy, the Netherlands and Scandinavia – as well as in South Korea, spending decreased, while rising a paltry 2-3 per cent in Japan and Germany.

These data, gathered by the International Energy Agency, contradict official statements. The chair of the most recent meeting of energy ministers disingenuously reported that Mission Innovation was "on track". That is true only in the most legalistic sense: many nations set their spending baselines unrealistically low, so they could easily claim to have doubled them. The gap between talk and action on energy innovation is disturbing.

Despite announcing its withdrawal from the Paris Agreement, the United States' clean energy RD&D budget has grown nearly 15 per cent since the signing of Mission Innovation. At $6.8 billion, it is larger than those of the countries ranked second and third (China and Japan) put together. US spending on basic energy science is larger than the rest of the Mission Innovation nations combined.

These levels were achieved, though, only because the US Congress rejected the Trump administration's proposed budget cuts. Beyond the budget, the US administration's head-in-the-sand attitude toward climate change has harmed global clean energy innovation, giving diplomatic cover to nations that continue to support dirty energy.

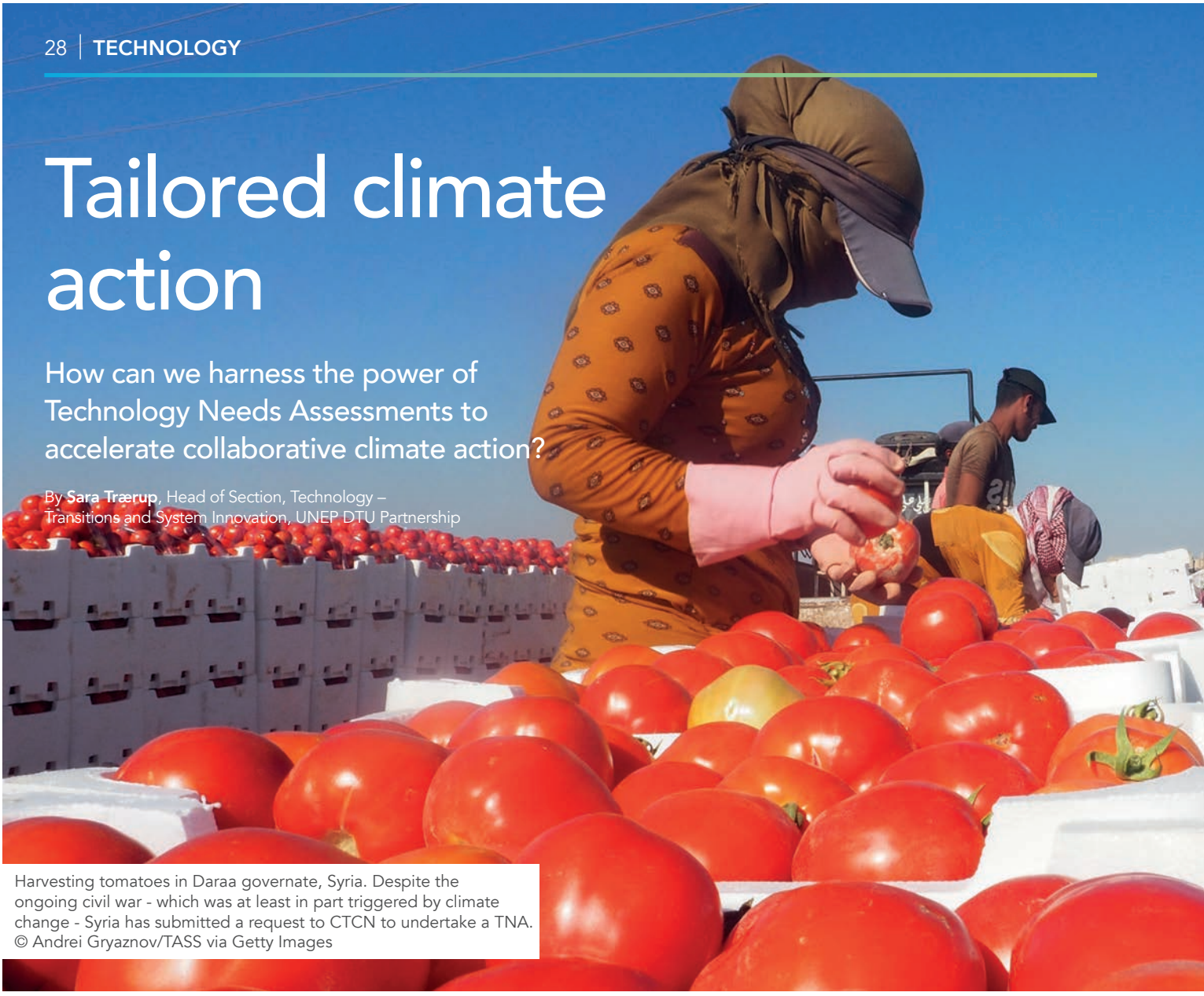
Moreover, the United States has largely abdicated its leadership role on the other dimension of Mission Innovation: international scientific and technological cooperation. Mission Innovation has identified eight global challenges where greater cooperation has the potential to dramatically accelerate progress, such as smart grids, carbon capture and sustainable biofuels. Each challenge is led by two to four countries. India and the EU hold three of these leadership roles apiece and are participating members in all of the other challenges. The United States is not leading any.

Like the Paris Agreement, Mission Innovation is only a starting point if the world is to truly avert the most damaging impacts of climate change. More ambitious efforts from national governments are needed. They should begin by fulfilling their commitments on RD&D spending and international cooperation, but then go beyond them and embrace a wider range of policy tools as well. ■

Tailored climate action

How can we harness the power of Technology Needs Assessments to accelerate collaborative climate action?

By **Sara Trærup**, Head of Section, Technology – Transitions and System Innovation, UNEP DTU Partnership



Harvesting tomatoes in Daraa governate, Syria. Despite the ongoing civil war - which was at least in part triggered by climate change - Syria has submitted a request to CTCN to undertake a TNA. © Andrei Gryaznov/TASS via Getty Images

Understanding what kind of technologies are best suited to a country's specific climate change situation is the starting point for effective climate action. Before investing in technologies that reduce greenhouse gas (GHG) emissions and adapt to climate change impacts, it is essential to assess and analyse a country's specific needs. This information can then be used to set priorities and identify appropriate technologies.

Technology Needs Assessments (TNAs) are designed to do precisely this type of in-depth analysis. Using national sustainable development plans as their starting point, TNAs strengthen countries' ability to analyse and prioritise climate technologies. TNAs can therefore guide nations towards implementing the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement.

TNAs were already introduced under the UNFCCC at COP7. This defined them as "a set of country-driven activities that identify and determine the mitigation and adaptation technology priorities of Parties" and "particularly developing Parties" (UNFCCC, 2001). TNAs are central to the work of Parties to the UNFCCC. They present an opportunity to track an evolving need for new equipment, techniques, practical knowledge and skills.

These are all necessary to mitigate GHG emissions and reduce the vulnerability of sectors and livelihoods to the adverse impacts of climate change. TNAs were directly referenced in the Paris Agreement. They also play a central role under the 'implementation' theme in the newly agreed UNFCCC Technology Framework, which is set to guide the Technology Mechanism of the UNFCCC.

From now on, supporting developing countries to conduct effective TNAs and implement Technology Action Plans (TAPs) will be instrumental to the UNFCCC process. A TAP is a medium to long-term plan for increasing the implementation of identified technologies. It outlines actions to be undertaken – further elaborated as project concept notes.

The TNA process

It is crucial to involve all relevant stakeholders throughout the TNA process. Any given technology is more likely to be understood, accepted, supported and implemented at all levels – from government ministries to farmers and households – if all stakeholders are involved.

The TNA process is organised around three main activities:

1. to identify and prioritise mitigation and adaptation technologies for selected sectors;
2. to identify, analyse and address barriers hindering the deployment and diffusion of the prioritised technologies, including the enabling framework for those technologies;
3. to conduct, based on the inputs obtained from the previous two steps, a TAP.

With funding from the Global Environment Facility (GEF), UN Environment (through UNEP DTU Partnership) supports developing countries through the global TNA project. The project helps countries determine their technology priorities to mitigate GHG emissions and adapt to climate change.

For each of the above steps in the TNA process, UNEP DTU Partnership has developed guidance and methodologies. These are available through the project website (tech-action.org). For example, in prioritising technologies, countries use multi-criteria analysis. This facilitates the participation of stakeholders and allows for normative judgements, while incorporating technical expertise into the TNA.

To ensure that men and women benefit equally from the actions set out in TNAs, and that gender inequalities in activities and outcomes are reduced or eliminated, gender considerations are taken into account throughout the entire TNA process and its outcomes. By systematically mainstreaming gender issues into the TNA, it is possible to ensure that women and men have equal opportunities in relation to the TAPs.

Success factors for implementation

A 2019 UNFCCC paper analyses success factors for implementing technology priorities, as identified and analysed on TNAs and TAPs. Some of these success factors include:

1. engaging stakeholders and ministries during the TNA and post-TNA to include TNA-prioritised technologies in new or ongoing government programmes, so that sector-level goals can be achieved with help of concrete actions from TNAs and TAPs; this also helps substantiate requests for funding from international programmes;
2. co-development of TNAs and TAPs with nationally appropriate mitigation actions and Nationally Determined Contributions (NDCs) – as well as GEF, Green Climate Fund (GCF) and Adaptation Fund pipelines or country programmes; this helps to mainstream TNA outcomes in overarching national strategies and programmes for climate and sustainable development;
3. development of pilots to demonstrate technological options, with financial support from multilateral programmes such as those managed by a range of development partners, and technical support and advice from the Climate Technology Centre and Network (CTCN) (training, pilot development, writing of concept notes for funding proposals, and so on).

TNAs and NDCs

It is more important than ever to plug the TNA process into existing sector-specific and other ongoing plans and activities, such as those related to the NDCs. Thanks to the information that TNAs provide about the potential, ability and scale of climate change technologies, they can play a unique role in the implementation of NDCs.

Actions identified in the TAPs highlight what needs to be done to activate robust market systems and the enabling conditions for technology diffusion and uptake. These actions can in turn strengthen longer-term strategies elaborated in NDCs and national adaptation plans and potentially raise ambitions by making the means of implementation more concrete.

An analysis of 71 countries' TNAs and NDCs showed that more than 70 per cent of countries who have done a TNA have integrated the results into their NDC. For example, priority technologies identified and assessed through the TNA process were included in Lebanon's NDC. When creating its NDC, Lebanon was able to build upon an existing assessment of prioritised technologies, complete with an analysis of the country's barriers and potential enabling measures to overcome them.

Flexibility is key. Indeed, TNAs should be used to formulate actions that can be integrated into governments' own planning processes. TNAs should also help create a pipeline of programmes and projects targeted at the GCF and other sources of multilateral and private finance.

In parallel, or as an intermediate step, countries can approach the CTCN. They can expect their requests to be 'favourably considered' provided they make explicit a connection with their TNA/TAPs, since the COP has mandated CTCN to build upon the TNAs. ■

HOW THE CTCN FITS IN

The CTCN is implementing technology projects in 93 countries on a wide array of adaptation and mitigation sectors, from agriculture, disaster-preparedness and energy to industry, pollution, water and waste management. These interventions come at the request of developing countries as they seek to fulfil their Nationally Determined Contributions (NDCs) and achieve their Sustainable Development Goals (SDGs).

It is therefore one of the premiere initiatives helping nations raise and realise their commitments under the Paris Agreement. CTCN helps countries to identify where they face challenges in meeting their goals and provide quick, targeted interventions in order to keep them moving forward. CTCN supports:

- technology prioritisation and piloting,
- policy and regulatory guidance,
- capacity building,
- entrepreneurship and market creation,
- and upscaling and financing.

CTCN leverages the expertise of the UN Environment Programme and UNIDO, along with a global network of over 500 civil society, finance, private-sector, and research institutions, as well as Nationally Determined Entities from over 160 countries in the Global South and North, to provide customised technology solutions.

Case study:

Harnessing wind energy in south Benin

A Climate Technology Centre and Network (CTCN) project examined the potential to develop a small wind turbine sector in Benin to bring power to rural communities in the West African country.

By **Peter Vissers**, Partner and Strategic Advisor, and **Stan van den Broek**, Advisor, Partners for Innovation BV

Like many coastal and windy regions in sub-Saharan Africa, Benin wants to harness the power of wind to generate electricity. The south of the country, with its coastline on the South Atlantic, is particularly rich in this natural resource.

Yet despite its geographical advantage in this regard, Benin's wind power generation has not taken off. One of the factors is cost: buying turbines from external suppliers is expensive.

But what if Benin could develop and build its own small-scale wind turbines? By setting up a local industry, wind technology may become more cost-competitive and easier to maintain. Besides providing electricity to rural communities who currently lack power, it could also create jobs for the local population.

> **By setting up a local industry, wind technology may become more cost-competitive and easier to maintain**

Benin therefore asked the Climate Technology Centre and Network (CTCN) to help test the feasibility of establishing a locally manufactured small wind technology sector in the country.

Project objective

Benin's Department of New and Renewable Energy requested support to conduct a feasibility study and develop an action plan for setting up a small-scale wind turbine sector. The study was to identify both barriers and opportunities for creating a local manufacturing industry of small wind turbines, as well as a market with potential for growth.

The project looked at both demand and supply. On the demand side, would enough people in rural communities currently without power want and use the electricity produced by local wind turbines? On the supply side, is there sufficient potential to establish and grow the infrastructure, finance, skills and workforce to successfully develop the sector? The objective of the action plan was to look at the immediate to long-term actions needed to develop the sector. It looked at four areas:

- sector programming;
- targeted implementation;
- coalition building;
- knowledge development.

Participants

The CTCN and the Department of New and Renewable Energy (Benin) commissioned the project. We at Partners for Innovation BV implemented it. We are a consultancy firm based in the Netherlands and Niger with experience in renewable energy project management and feasibility studies.

We worked with a Dutch wind turbine specialist, a Beninese energy technology manufacturing and supply-chain specialist, and a Togolese gender assessment specialist.

Benin's country representative and CTCN focal point for the project was Raphiou Aminou, of Benin's Directorate General for Climate Change.

Challenges

A key challenge was to keep the project focused and to manage expectations. Direct and regular communication between Partners for Innovation, the CTCN and Benin's Department of New and Renewable Energy helped to achieve this. The Energy Department also organised meetings with local stakeholders, which helped to convince the latter of the benefits of the project, as well as generating widespread media coverage.

The project showed that future success of the sector will depend upon utilising the relevant networks of project participants to organise high-profile, in-country meetings with key partners and decision-makers.

Ouidah, Benin. The southern coast of Benin benefits from abundant wind potential. © Peeter Viisimaa/Getty Images

Another challenge was how to transfer technical knowledge and expertise to the local workforce – an essential element of the sector's future success. One of the key lessons learnt from the project was the need for international technical experts to cooperate with local experts. This will allow for both in-depth knowledge transfer and lower production costs as expertise grows within Benin.

Climate action

The project shows that enabling the production of small wind turbines in Benin has the potential to reduce greenhouse gas emissions in the country's rural and peri-urban areas by 5 kilotons of CO_2e every year.

It will also contribute to the country's Nationally Determined Contribution (NDC) goal of increasing domestic renewable energy production. In total, Benin can expect to produce 7.7 GWh of renewable energy each year if all the locations identified in the project are electrified. The project shows that wind speeds are high and reliable enough for generating significant kilowatt hours of energy.

The project's action plan contributes to Sustainable Development Goal (SDG) 13 on climate action, as it provides clear steps to follow for stimulating clean energy production in Benin. And we hope that the project will also help to engage private investors in climate action – one of the key targets of the UN Framework Convention on Climate Change.

Other benefits

The project contributes to Benin's NDC goal of increasing household energy access. If the sector is developed as hoped, some 200,000 people will have access to affordable, reliable, sustainable and modern energy (SDG 7).

The project highlights the potential to develop local industrial capacity and provide jobs for local communities, particularly young people. The results of the CTCN's technical assistance also have the potential to be replicated and scaled up at regional level through relevant financial mechanisms – both institutional and private.

Longer-term, as the sector matures, the project shows that Benin would have the potential to generate income through exporting small wind turbine components, systems and knowledge. ■

KEY FACTS

Organisations involved:
CTCN, Department of New and Renewable Energy (Benin), Partners for Innovation BV (Netherlands)

Budget:	$83,075
Start date:	1 July 2017
Completion date:	31 July 2018

Benefits:
Identified potential to develop wind turbine sector in Benin, which could cut 5 kilotons of CO_2e, generate 7.7 GWh of renewable energy per year and connect 200,000 people to clean energy supply.

The power of renewables

Renewable energy can lead the way to sustainable development and climate mitigation.

By **Francesco La Camera**, Director-General, International Renewable Energy Agency (IRENA)

On the borders of the UNESCO World Heritage Site of Banc d'Arguin National Park in Mauritania, the new village of Chami is powered by a combination of wind and solar. © Freya Morales/UNDP

At the Climate Action Summit in September 2019, UN Secretary-General António Guterres urged the global community to act. An environmental catastrophe that once seemed abstract is now at our doorstep.

We have less than 11 years to cut carbon dioxide emissions and limit the rise of global temperatures, according to the Intergovernmental Panel on Climate Change report. Otherwise, our world faces irreversible consequences.

Holding the line on rising global temperatures by the end of the next decade is a daunting challenge. But it is possible. Solar, wind and other renewable energy sources, together with improved energy efficiency, represent the most effective and ready solution to reduce energy-related emissions. They are practical, affordable and climate-safe. No other technology offers as plausible a path to reducing energy-related emissions within a decade.

In what has become a race against time, the universal availability and immediately deployable nature of renewable energy makes it a most potent climate response. The speed at which renewable energy plants can be built and made operational is impressive. Installing a solar PV and wind farm can be completed in a matter of eight to 12 months, depending upon the size and complexity of the project. Building a fossil fuel power plant takes years, and a nuclear plant even longer. In addition, renewable energy systems can be sized precisely to the needs, however small or large the project requires.

Speed is not the only advantage of renewable energy. In tackling climate change with renewables, we can lead the world into a new age of sustainable development. The post-carbon era promises to bring opportunity even to the poorest countries, lighting up economies left behind

by resource inequality. A climate-safe energy path would grow the global economy by 2.5 per cent and would create more new, sustainable energy jobs than those lost due to the phase-out of fossil fuels. Energy transition is a tremendous opportunity for developing countries.

According to our analysis, sub-Saharan Africa could have, by 2050, the highest shares of renewable energy in primary energy supply with levels far above 80 per cent. However, Africa's energy leapfrog will only be possible if the flow of capital to projects can be scaled up significantly, and the necessary human capacity can be built.

Renewables are also key to climate resilience in developing countries. While Small Island Developing States (SIDS) and the Least Developed Countries (LDCs) have only marginally contributed to climate change, these nations are acutely vulnerable to its consequences. Many of them show strong ambition in the pursuit of renewable energy, which can deliver climate resilience, energy security and energy access.

The SIDS renewable energy initiative, which was launched at the Climate Summit, is a testament to this. Developed by Palau and the Alliance of Small Islands States (AOSIS), the initiative includes an objective to achieve by 2030 as much as 100 per cent renewable energy, in particular in the power sector. Its implementation will leverage the already operational and successful SIDS Lighthouses Initiative.

IRENA together with UNDP and SEforALL, in cooperation with the GCF, also launched at the Climate Summit an initiative that aims to unlock the capital necessary to advance climate-resilient low-carbon energy solutions – especially in those countries that need it the most, such as the LDCs and SIDS.

The Climate Investment Platform (CIP) is an inclusive partnership welcoming all stakeholders including governments, international organisations and the private sector to scale-up climate action and translate ambitious national climate targets into concrete investments on the ground. We are convinced that the CIP will help bridge the gap between supply and demand to accelerate capital and scale up climate resilient investments, allowing countries to raise their climate targets and develop policy environments that allow investment to flow.

Investing in renewables

To reach the transformational speed required, global energy investment must overwhelmingly pivot to renewables. Annual investments in renewables would have to rise from today's $330 billion to more than $750 billion per year. In other words, an investment gap of more than $400 billion needs to be closed – and quickly. Redirecting $19 trillion of fossil fuel investments earmarked until 2050 into more socially and economically beneficial low-carbon technologies including renewables, is imperative. We have to turn our back on coal entirely.

> **The opportunities presented by sustainable energy should prompt global leaders, investors and policymakers to rethink strategies**

By 2050, a rapid uptake of renewables combined with energy efficiency and electrification would avoid $10 trillion of energy subsidies heavily weighted towards the fossil fuel industry. In fact, every dollar spent on the energy transition would offer returns of up to three to seven times in improved human health, lower climate related expenditure and reduced subsidies.

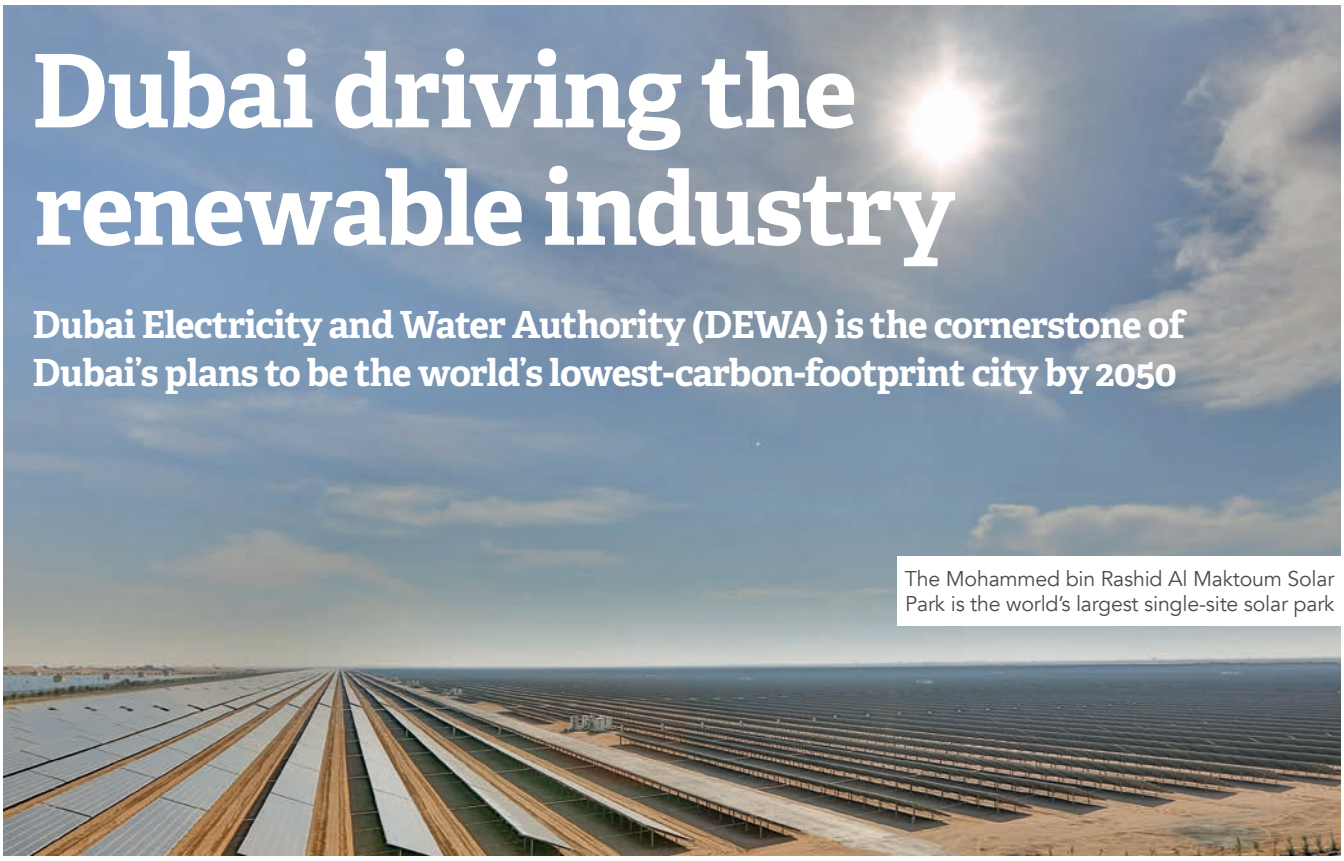
Finally, continuous cost reductions for renewable energy provide a big opportunity. In many countries, including the United Arab Emirates where IRENA is based, generating power from renewables is now cheaper than the least cost traditional energy alternative. This trend is bound to continue.

The opportunities presented by the shift to sustainable energy should prompt global leaders, investors and policy makers to rethink strategies. IRENA is doing just that. We have built a knowledge framework around renewable energy that has become an indispensable source of global data. But the time has come for action on the ground. That's why we are adjusting our structure, focus and goals to move closer to implementation and to position ourselves as a partner on the ground to our members.

The message is clear. It's possible to hold the line on global emissions within the next 11 years. It's possible to avert irreversible climate change and mitigate the impacts of a warming planet. And it's possible to achieve a global energy system that is equitable, accessible and clean. Renewables are to lead the charge. ■

Dubai driving the renewable industry

Dubai Electricity and Water Authority (DEWA) is the cornerstone of Dubai's plans to be the world's lowest-carbon-footprint city by 2050



The Mohammed bin Rashid Al Maktoum Solar Park is the world's largest single-site solar park

The UAE has already taken steps to bid farewell to its last barrel of oil, by striking a balance between sustainable development and maintaining a clean, healthy and safe environment.

The UAE Energy Strategy 2050 aims to achieve an energy mix that combines renewable and clean energy sources to balance its economic requirements with environmental goals. Up to 2050, the UAE will invest AED 600 billion to meet growing energy demand and ensure the sustainable growth of the economy.

Climate change remains a priority on the UAE Federal agenda. In 2017, the UAE Federal Government introduced a National Climate Change Plan, as a roadmap to mitigate and adapt to climate change in the UAE until 2050.

The Government of Dubai has set its own ambitious strategies, such as the Dubai Carbon Abatement Strategy, with a target to reduce carbon emissions by 16% by 2021, which it has already exceeded with recorded emissions reduced by 19% by the end of 2018.

The Dubai Clean Energy Strategy 2050 aims to provide 75% of Dubai's total power output from clean energy by 2050. The strategy consists of five main pillars: infrastructure, legislation, funding, building capacities and skills, and having an environmentally friendly energy mix. The Mohammed bin Rashid Al Maktoum Solar Park is one of the key projects to achieve Dubai's vision to make its carbon footprint the lowest in the world by 2050.

Mohammed bin Rashid Al Maktoum Solar Park

The Mohammed bin Rashid Al Maktoum Solar Park is the largest single-site solar park in the world, with a planned capacity of 5,000 megawatts (MW) by 2030, at a total investment of AED 50 billion (USD 13.6 billion) and will eventually save approximately 6.5 million tonnes per annum in emissions. The solar park will use a range of photovoltaic and concentrated solar power (CSP) technologies to provide clean energy to the citizens and residents of Dubai. It incorporates an Innovation Centre, a Research & Development Centre, testing facilities and a solar-powered water desalination plant.

The solar park is also using public-private partnerships to drive its expansion. It has successfully adopted the Independent Power Producer (IPP) model and is being developed in phases, with the 13MW first phase becoming operational in 2013 using photovoltaic panels. The 200MW photovoltaic second phase became operational in March 2017. The 800MW photovoltaic third phase will be operational by 2020 and is being developed in three main stages.

The third phase of the solar park, with a capacity of 800MW using photovoltaic solar panels, recorded another world record in the cost of photovoltaic solar power for this phase of the solar park, at a Levelised Cost of Energy (LCoE) of USD 2.99 cents per kilowatt-hour. The first stage of the 800MW has a capacity of 200MW and became operational in May 2018. It uses unique technologies,

> **The Dubai Clean Energy Strategy 2050 aims to provide 75% of Dubai's total power output from clean energy by 2050**

including over 800,000 solar modules that use robots for cleaning to maintain efficiency. This stage provides more than 60,000 residences with electricity, reducing over 270,000 tonnes of carbon emissions every year. The second stage has a capacity of 300MW and has been operational since mid-August 2019. The third stage is under construction and will be operational by 2020.

The fourth phase of the solar park is the largest single-site solar IPP project in the world that combines CSP and photovoltaic technology. This phase will use three technologies to produce 950MW of clean energy, which will include a total of 700MW from CSP: 600MW from a parabolic basin complex and 100MW from a solar tower; as well as 250MW from photovoltaic panels. This phase will provide clean energy for 320,000 residences and will reduce 1.6 million tonnes of carbon emissions a year.

The project will cover 44 square kilometres, and the world's lowest LCoE for CSP of USD 7.3 cents per kilowatt-hour combined with the lowest LCoE for photovoltaic technology of USD 2.4 cents per kilowatt-hour. The project will have the tallest solar tower in the world at 260 metres in height and the largest thermal storage capacity of 15 hours; allowing for energy availability round the clock.

The solar power projects that are currently operational at the solar park have a capacity of 713MW. DEWA is currently implementing three more projects with a capacity of 1,250MW at the solar park. Recently, the fifth phase of the solar park was announced with a capacity of 900MW electricity using photovoltaic panels, which will increase the current total capacity under construction to 2,863MW, demonstrating DEWA's intent to reach its 5,000MW capacity target by 2030.

DEWA's Research & Development Centre

The solar park not only combines the efforts of the public and private sectors in solar power, but it is also home to one of the largest research & development (R&D) centres in the region. The R&D Centre focuses on research into producing electricity using solar power, integration of smart grids and water.

On-site solar testing facilities

The solar park features two solar testing facilities: the first tests photovoltaic solar panels, the other focuses on CSP. The facility is currently testing 30 photovoltaic panels from global specialist manufacturers to check their properties, analyse results and use them in R&D. The solar testing facility will focus on mitigating the effects of dust soiling on photovoltaic panels, and developing technology to withstand the regional climate.

Introducing hydrogen to the UAE energy market

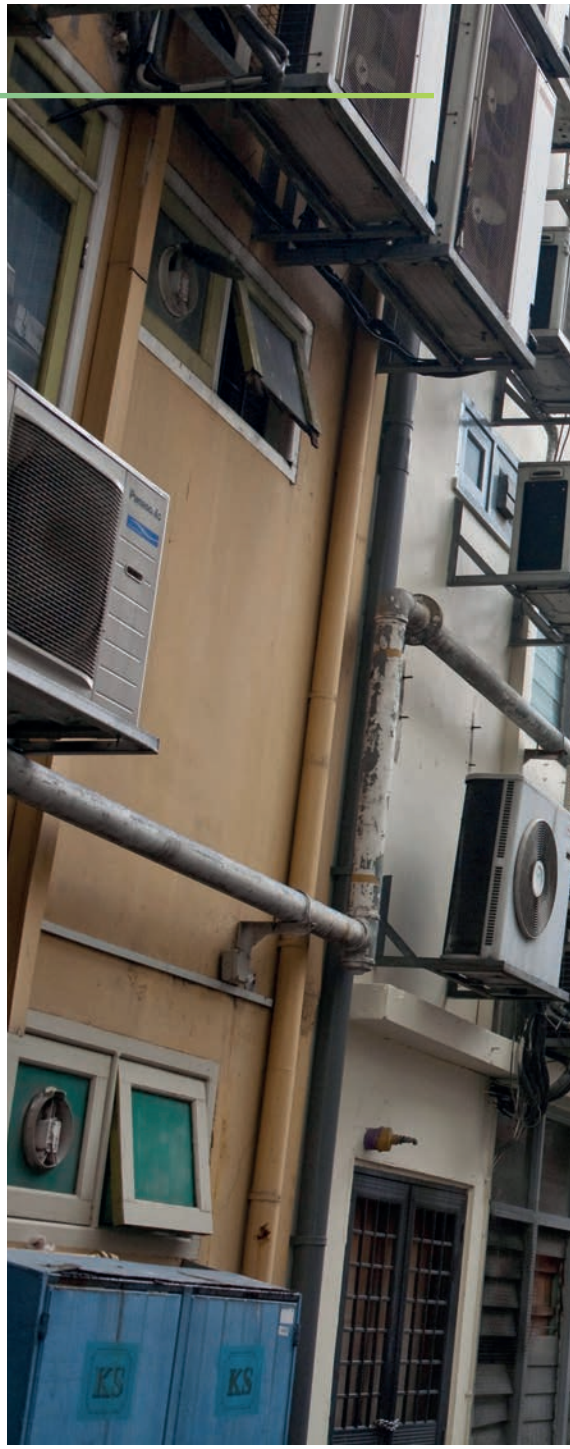
DEWA is working to develop a solar-powered hydrogen electrolysis pilot facility at the solar park. It will produce green hydrogen from solar power, store and use hydrogen for various downstream applications (such as re-electrification and re-injection of power into the grid) as well as transportation and mobility.

The pilot facility will research, test and demonstrate end-to-end technical solutions related to the development of a hydrogen economy in the UAE, which could play a role in addressing the energy challenges of the future.

A pilot solar-powered desalination plant

Finally, the solar-powered water pumping and desalination station at the solar park uses photovoltaic solar panels to desalinate water with reverse osmosis technology, with a production capacity of 50 cubic metres (around 11,000 gallons) a day. The project is a collaboration with the UAE Water Aid Foundation (Suqia), under the umbrella of Mohammed bin Rashid Al Maktoum Global Initiatives, to find innovative and sustainable solutions to combat global water challenges and provide clean, potable drinking water.

The Innovation Centre is a key part of the solar park



Energy efficiency, the obvious first response

The technology and expertise are there, so what's stopping countries from maximising their efficient use of energy?

By **Brian Motherway**, Head of Energy Efficiency, International Energy Agency (IEA)

Energy efficiency is one of the most effective means to mitigate climate change. According to analysis by the IEA, energy efficiency measures can deliver nearly half of the total emissions reductions needed to meet the goals of the Paris Agreement. Crucially, all the efficiency measures needed to deliver that volume of emissions reductions are cost-effective, and based on the use of existing technologies. In other words, efficiency is available now.

In addition to mitigating climate change, energy efficiency offers a range of social, economic and environmental benefits. It enables people to benefit from all the good things energy brings, but at a lower cost and with a lower environmental impact. Efficient industries are more competitive, efficient countries are more energy-secure, and efficient buildings are more comfortable, healthier and cheaper to run.

A worrying slowdown

Despite the huge potential of energy efficiency, the world continues to face challenges in capturing its benefits. In 2018, global energy demand grew by 2.1 per cent, the largest increase since 2010. This increase in demand was accompanied by the highest rate of growth in energy-sector greenhouse gas emissions since 2011. Energy efficiency is helping to offset the impact of some of that growth in demand and emissions. However, energy intensity – the energy required to produce one unit of global gross domestic product (GDP) – improved by just over 1.3 per cent in 2018. This is well below what is possible from greater action on energy efficiency, and is the third year in a row that improvements in global energy intensity have slowed.

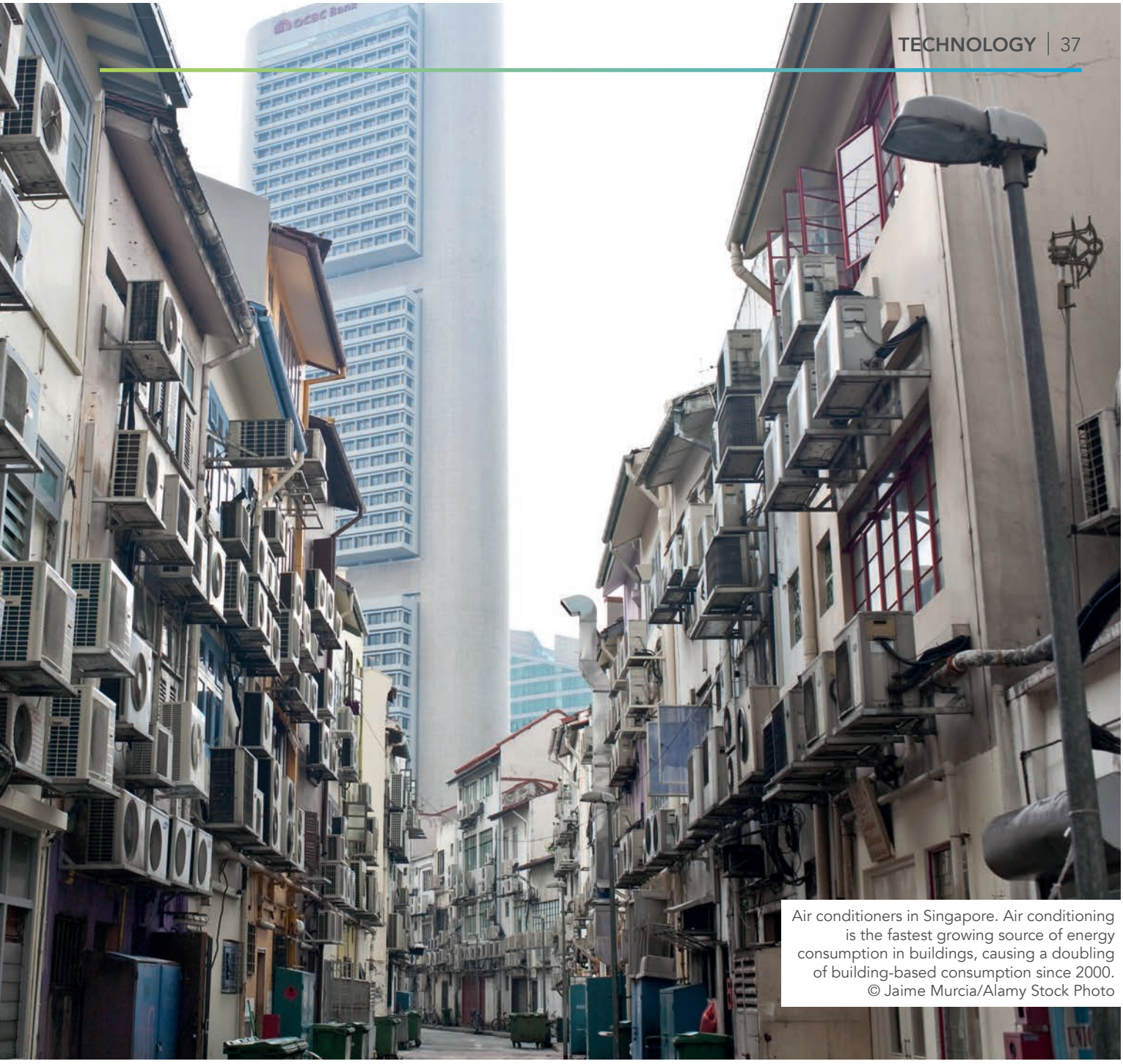
Raising the profile

In light of this global efficiency slowdown, there is a growing recognition across the planet that efficiency efforts need to be stepped up. For example, a new high-level Global Commission for Urgent Action on Energy Efficiency was established in June 2019 to examine how progress on energy efficiency can be rapidly accelerated through new and stronger policy action. Irish Prime Minister Leo Varadkar is honorary chair of the initiative, which includes heads of state, current and former ministers, CEOs and efficiency thought leaders. Supported by IEA analysis, the Global Commission will focus on key policy actions to drive global efficiency action, producing a concise set of clear, actionable recommendations by the summer of 2020.

Transforming ambition into action

While it is critical to reserve a seat for efficiency at the top table, so to speak, there is equally a need to ensure that efficiency measures are implemented 'on the ground' both in emerging as well as developed economies. In that respect, policies are critical for transforming high-level ambitions into concrete actions. Without policies, the potential of energy efficiency simply cannot be realised. For example, with more than two thirds of global energy use not covered by any mandatory energy efficiency policies, a great deal of work remains to be done in this regard.

Fortunately, governments wishing to realise more of the benefits of efficiency do not need to start from scratch. Decades of accumulated global experience demonstrate that well-designed energy efficiency policies can bring huge social and economic



Air conditioners in Singapore. Air conditioning is the fastest growing source of energy consumption in buildings, causing a doubling of building-based consumption since 2000. © Jaime Murcia/Alamy Stock Photo

Well-designed energy efficiency policies can bring huge social and economic benefits

benefits. The Climate Technology Centre and Network (CTCN) has worked with 41 different governments around the world to deliver a range of energy efficiency projects.

Minimum energy performance standards (MEPS) are often the key component of any efficiency policy framework. MEPS regulate the amount of energy consumed by technologies, such as refrigerators, light bulbs or electric motors, which account for more than half of global electricity consumption, according to the IEA. They can be cost-effective and act as a cornerstone of governments' climate change mitigation programmes, assuming they meet a number of conditions. Accurate market data, for example, is critical to ensure standards are set at levels that move the needle on efficiency without creating undue costs for companies and consumers. Proper implementation and enforcement, backed by incentives and penalties if necessary, are also important to ensure standards work as intended.

Further action

While over 80 countries have adopted MEPS, covering more than 50 different types of technologies in different economic sectors, more action is needed. This is true

especially when it comes to mitigating the emissions impact from a rapid growth in sales of energy, using technologies without undermining their positive economic and social benefits.

Cooling equipment, notably air conditioning (AC) units, is an important example of this dynamic. Energy use in buildings – largely from AC – has doubled since 2000, making it the fastest-growing source of energy consumption in buildings, IEA figures show. Driven by population growth and rising incomes, particularly in the hottest parts of the world, global sales of AC units are set to soar.

Without efficiency gains, space-cooling energy use could more than double between now and 2040, with worrying implications for the climate. Access to affordable cooling is an important social issue – in some cases, it can be a matter of life or death. In that respect, robust MEPS for AC, for example, can help governments ensure that their populations get access to cooling services without placing undue stress on the climate.

MEPS are critical for achieving a gradual transformation of markets and replacing inefficient with efficient equipment. Bulk procurement of efficiency services or products, meanwhile, can get efficient technologies into the hands of consumers rapidly, while bringing down costs dramatically through economies of scale. India, for example, is deploying millions of efficient lights through a national programme called UJALA. This has already delivered more than 360 million lamps across the country, providing access to affordable lighting for millions of poor rural and urban households.

These are just two examples of how efficiency policies can allow governments to achieve climate and energy objectives while addressing a range of other social, economic and environmental concerns. With rapid innovation in the field of digitalisation, efficiency policies have an even greater potential to transform the way that energy is used, with important implications for policymakers.

Digitalisation enables much greater levels of precise control of energy use, at very low cost. It also enables a shift away from thinking only about end-use efficiency (e.g. more efficient appliances) to a system-wide perspective. In an age of fast-growing deployment of clean and cheap energy sources, particularly on electricity grids, a vital goal is not just to maximise the efficiency of end use but also the efficiency of the whole system.

Conclusion

Now is the time to open a new chapter in the story of a more sustainable energy future. With the right support and attention from governments, and with smart, effective policies, energy efficiency can take a leading role in this story. Countries need to act. Decisive action on efficiency can transform a worrying slowdown into an inspiring success. With a wealth of global experience in policymaking, and in an era of digital innovation, there is no reason why countries should wait any longer to realise the full potential of efficiency. ■

> **Countries need to act. Decisive action on efficiency can transform a worrying slowdown into an inspiring success**

GREEN COOLING AFRICA INITIATIVE (GCAI)

Context

Refrigeration and air conditioning appliances (RACs) are rapidly spreading across Africa. As the electricity in most African countries is still generated through burning of fossil fuels, increased demand for energy results in increased greenhouse gas (GHG) emissions.

With the use of highly energy efficient RACs and the substitution of high global warming potential (GWP) refrigerants with low GWP refrigerants and foam blowing substances, both GHG emissions and energy use can be substantially reduced. Alternative technologies are internationally available but not common in Africa. Together, the CTCN and the International Climate Initiative of the German Environment Ministry implemented the Green Cooling Africa initiative, which aims at establishing a prototype best practice approach for Ghana, Kenya, Mauritius and Namibia.

CTCN response

- Establish a robust GHG Inventory for selected, priority cooling sub-sectors.
- Analyse the technological gap between existing technologies and internationally available green cooling technologies.
- Propose recommendations.
- Develop regional and country specific technology roadmap recommendations.
- Capacity building and NAMA institutional setup.
- Seek funding and/or co-funding for implementation.
- Key technologies addressed.
- Efficient air conditioning systems.
- Shift to cooling agent with lower GWPs.

Expected results

- Potential GHG mitigation of 30 per cent over current estimates through 2030
- Reduced electricity consumption
- Decreased use of fluorinated and chemical substances that produce persistent atmospheric wastes
- Sustainable development benefits (income and employment generation, foreign exchange savings, increased energy security, etc.).

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Unlocking access to water

Just as the climate crisis affects water resources, water infrastructure systems aggravate climate change by producing direct and indirect greenhouse gases (GHGs). Can technology provide an answer to this conundrum?

By **Thomas Panella**, Chief of Water Sector Group and **Stephane Bessadi,** Senior Water Utility Specialist, Asian Development Bank (ADB)

Technology has always been a driver of the water supply sector. As cities mushroomed and demand for water increased, the sector relied on local water resources until water purification techniques were introduced in the early 19th century. Then, as urban populations grew, the need for improved public health saw the development of piped water systems. These utilised various pipe materials throughout the 20th century: copper, cast iron, steel and, later, PVC and other plastics. These pipes enabled the spread of water transmission and distribution systems, providing water to households, communities and industries. In turn, this spurred economic development and longer lifespans.

Demand and supply

Today, the amount of fresh water needed to satisfy global demand is enormous. Although water makes up 70 per cent of the Earth's surface, less than 3 per cent is fresh water, and less than 1 per cent is accessible. From irrigating farmlands to producing jeans and paper, fresh water is required everywhere. And yet it could soon be lost in many places around the world. More than a billion people currently live in water-scarce regions. By 2050, nearly 5.7 billion people will face water restrictions for at least one month every year, according to a 2019 World Resources Institute report.

The World Health Organization estimated that in 2015, 2.1 billion people worldwide lacked safely managed drinking water. In Asia and the Pacific, there are still about 260 million people relying on unimproved water sources, using drinking water from an unprotected dug well or unprotected spring. The development and management of water resources, infrastructure and services in the region have mostly been insufficient, significantly lagging behind the rate of urbanisation. Not only are resources constrained, but so are the governance and organisation of the institutions responsible for them. Many suffer from outdated technical, managerial and tariff models.

In the last three decades, climate has become a compounding factor. Climate change, including the fact that changes in precipitation patterns are expected to intensify floods and droughts, is affecting the quantity of available surface and groundwater. So we urgently need new ways to protect and conserve these precious resources. Meanwhile, sea-level rise is causing saline intrusion into coastal aquifers, contaminating freshwater quality.

The latest UN report on progress towards the Sustainable Development Goals (SDGs) presents a bleak update on SDG 6 ("ensure availability and sustainable management of water and sanitation for all"). The report states: "More efficient use and management of water are critical to addressing the growing demand for water, threats to water security and the increasing frequency and severity of droughts and floods resulting from climate change."

The cases of severe water shortage in a number of cities, including Chennai and Manila in 2019, are a stark reminder that water resources are depleting while urban water demand is continuously increasing.

Water and GHGs

While the effects of climate change on water access are known, we must not overlook the fact that the infrastructure needed to address water supply issues or improve access to water requires a lot of energy. Water and wastewater systems have their own carbon footprint from indirect emissions, due to the electricity consumed for operations (such as pumping). They are also responsible for direct GHG emissions during wastewater treatment. While these systems may not be major contributors to global warming (unlike the fossil fuels and livestock industries), we still need action to minimise their emissions. This is especially true if we consider that water and wastewater coverage in developing countries is bound to expand as these countries progress.

Water utilities need to find energy efficiency gains and clean-energy alternatives. But they also need to find a better way to manage water resources, if they are to serve an ever-growing population in a way that does not harm the planet and future generations.

So, can technology transform the water supply sector again, as it did in the past?

The answer is yes. In Asia and the Pacific, where the need is particularly acute, water utilities need to capitalise on the digital revolution to optimise infrastructure, operations and institutions. The use of

Water utilities need to find energy efficiency gains and clean-energy alternatives

Students fill their water bottles at a high school in West Bengal, India. The rural population in the region is heavily reliant on groundwater that is at risk from arsenic and fluoride contamination. © Hamish John Appleby/ADB

To achieve SDG 6, innovation matters. It starts by applying technology for good water utility operations

technology, properly operated, will allow utilities to do two key things. First, improve access to water in the face of climate change and water scarcity. And second, reduce the climate impact of water supply systems through improved efficiency and alternative clean-energy sources.

Improving access to water to tackle climate change

Cities typically use water from surface, underground and (to a lesser extent) desalinated water. A 2014 study by Julie Padowski and Steven Gorelick, *Global analysis of urban water supply vulnerability*, looked at 71 cities supplied by surface water. The study showed that 45 per cent of these cities will become vulnerable due to increased agricultural and urban demands by 2040.

As for underground water, its usage and exploitation should respect aquifer capacity. Over-abstraction causes reduction of the water table and contamination of the aquifer. It can also cause land subsidence, as in the case of Jakarta and many other coastal cities in Indonesia, prompting the government to consider moving its capital city. When no other sources are available, expensive and energy-demanding desalination plants are the final option.

Obviously, pushing nature's limits in this manner is not sustainable, even though the current world economy and development model may argue otherwise. Innovative technologies already exist to better manage water resources with accuracy and reliability. In Rajasthan, India, ADB is supporting the government to introduce a SCADA (supervisory control and data acquisition) system, which integrates remotely connected flow meters. The SCADA will help the state to more efficiently control the quantity and quality of water resources supplied. It will also allow it to detect anomalies, such as inadequate water resources or pollution, so that swift corrective actions can be taken.

Every drop counts in today's context. So much so that one of the major challenges to access and supply is non-revenue water (NRW). This is water lost to leakages and pilferage stemming from low-quality infrastructure, insufficient funding and inadequate management of the water network.

These issues are aggravated by low water tariffs and inappropriate governance and regulation of the water service. While NRW levels are generally between 10 and 20 per cent in developed countries, they are around 50 per cent on average in Asia and the Pacific and can reach up to 75 per cent in highly deteriorated systems. Imagine the amount of water wasted – water that has already been sourced, treated and pumped!

Smart systems help to better understand assets' performance by integrating geographic information and mapping systems with asset and customer management systems. Utilities can now also use pressure management and leak detection technology to reduce water losses, especially when leaks are not visible from the street. The technology can also help them to achieve continuous pressurised supply. This, in turn, has a positive impact on infrastructure and water quality, since it minimises pressure surges and contamination. Finally, smart water meters provide valuable data about the amount of water supplied to and used by customers.

In Dhaka, Bangladesh, ADB helped the public utility to become a model for the rest of the South Asia region by reducing NRW from over 50 per cent to less than 10 per cent. It did this through the development of district metered areas (DMAs), along with other important interventions. The DMAs included flow meters, which enabled the utility to control flows and pressures at the local level.

As a result, over five million slum dwellers now have continuous water supply. Previously there was limited or intermittent supply, or people had to make do with contaminated water. Aside from giving people access to clean water, it has also meant less exposure to waterborne diseases and increased productivity and livelihood, particularly for women and children.

So, investment in water technology can help to meet the targets within SDG 6. Target 6.1 is to "achieve universal and equitable access to safe and affordable drinking water for all", while target 6.4 is to "substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of fresh water to address water scarcity, as well as substantially reduce the number of people suffering from water scarcity". Yet the return on investment for adopting these technologies far exceeds addressing SDG 6.

The development of an equitable and continuous water supply in a city also supports SDG 4 on good health and wellbeing, SDG 5 on gender equality, SDG 10 on reduced inequality, SDG 11 on sustainable cities and communities, and SDG 1 on ending poverty.

Reducing the climate impact of water systems

Maintaining the energy efficiency of water systems can be a challenge. Their energy use is heavily dependent on the amount of water pumped. On average, about 60 per cent of the energy used in water systems is used for pumping (according to INNERS 2015 literature review: *An overview of energy used within the urban water cycle*). These systems are greatly affected by terrain, pressure management and NRW (due to pipe degradation, illegal connections and inadequate operations management). Therefore, the greatest impact on energy use for water systems is to effectively manage pressure within the system, which can also reduce NRW.

For wastewater systems, the energy use and potential production of energy or resources is typically more complex. However, the biggest use of energy usually comes from wastewater treatment, specifically secondary biological treatment through aeration. Systems are now capable of operating at 'energy neutral', when considering both treatment and recovery of energy or resources. Advanced wastewater treatment systems have been developed to hydrolyse, dry or stabilise biosolids and produce energy and organic soil fertilisers,

for instance. The systems have also been used to extract energy in the form of heat in colder climates and to generate hydropower on wastewater treatment outfalls.

To address climate change vulnerability and promote energy efficiency advances in water and wastewater technologies, ADB developed the Screening Tool for Energy Evaluation in Projects (STEEP) for water and wastewater systems in 2017. This tool has been piloted on several projects, which have identified potential energy savings ranging from 20 to over 50 per cent, compared with the energy use/production of the implemented design. If such savings can be achieved, even as water and wastewater coverage increases in Asia and the Pacific, then surely this is a welcome contribution to reduce GHG emissions.

A recent study in Georgia by the Cities Development Initiative for Asia demonstrated the strong linkages between the high power costs for a water utility and high NRW. Through better leakage control, as well as recommended measures towards proper management, billing and operations could result in electricity savings of up to 50 per cent.

This is a great opportunity to build the same water and energy-efficient systems around the world and in Asia and the Pacific, which would 'kill two birds with one stone' (or water two plants with one hose). This is especially true if we consider the internal leakages faced in many homes and buildings in developing countries.

One of the co-authors of this paper was not immune to this and recently experienced a high amount of leakage in his own home. It took time to convince the landlord to get it repaired, as he is paying neither the water nor electricity bills and therefore does not see it as a priority. Once it was fixed, the internal water pump was running far less and water and electricity consumption reduced drastically.

Now, imagine multiplying this at a community level, then a city level, and then a country level. There will be substantial cost savings, which can then be channelled to other development priorities. There will also be significant power savings, which will mean fewer GHG emissions. In addition, the water saved will translate to less groundwater abstraction and better managed water resources.

The lack of genuine radical action galvanised youth worldwide to take to the streets in September 2019 for a climate strike. Water and wastewater systems may not be the biggest factors in terms of climate impacts and action. But when you consider how future systems can hope to cover population needs in places like Asia and the Pacific, the importance of water technology is obvious.

To achieve SDG 6 – water and sanitation for all – innovation matters. It starts by applying technology for good water utility operations. In terms of cost, it is cheaper for consumers. It terms of climate, it is healthier for humanity. Let us measure and reduce energy consumption and water losses for all cities – and implement genuine change. ■

WATER SUPPLY MANAGEMENT IN GRENADA

CTCN is currently implementing a project to improve water supply management in Grenada, which will use a Geographical Information Systems (GIS)-based monitoring and control system to reduce water loss.

As a small island developing state, Grenada is one of the world's most at-risk countries from climate change. The island experienced major droughts in 2010 and 2012, which significantly impacted water supply.

Once the project is complete, improved management systems will enable faster response to leaks; support preventative maintenance and the upgrading of pipelines; develop staff technical expertise; and help promote climate-smart water services and water resource management.

For further information, visit: www.ctc-n.org/technical-assistance/projects/improvement-water-supply-management-through-gis-based-monitoring-and

The Water-Energy-Food Nexus

Ensuring enough water, energy and food as the population grows and climate warms calls for smart solutions that recognise the interplay between finite resources.

By **Olivier Dubois**, Senior Natural Resources Officer, Food and Agriculture Organization of the United Nations

Planting onions in irrigated fields in Tamil Nadu, India. The projected 60 per cent growth in global food demand by 2050 will largely be fulfilled by yield improvements, which in turn will drive demand for water and energy. © Hamish John Appleby/ADB

Water, energy and food are essential for human wellbeing and sustainable development. They are also closely intertwined: water and energy are essential inputs to food production; water is often needed to produce energy; and energy is needed to pump water. But the current way we manage the links between these resources – the Water-Energy-Food (WEF) Nexus – is unsustainable. On the one hand, many people lack access to these essential resources. On the other, food production uses already an unsustainable amount of water and energy.

If we keep doing business as usual, the challenges in these sectors will only increase. By 2050, the world is forecast to need 60 per cent more food than it does now, which will mostly be procured through increasing yields, hence using relatively more energy and water. By 2030, the global energy demand is projected to grow by 40 per cent over current levels, which in turn drives further demand for water use for energy production.

These challenges are accentuated by the fact that we are starting from a point where, in many places, natural resources are already under stress, and the changing climate is increasing that stress.

To meet these challenges, we need to 'do more with less'. We also need to collaborate and be innovative in relation to water and energy use in food production. A WEF Nexus approach helps us to better understand the complex and dynamic interlinkages between water, energy and food. It can help us to manage these limited resources sustainably, taking into account different economic, social and environmental goals. Based on this, we can identify trade-offs and synergies, and we can design, appraise and prioritise response options and interventions.

Water, energy and food security are recognised as Sustainable Development Goals (SDGs) in their own right. Yet the fact that progress towards most of the SDGs is directly related to the sustainable use of resources such as land, food, water and energy has not been given adequate consideration in SDG implementation. The WEF Nexus approach can help in the implementation of the SDGs by:

- identifying potential trade-offs at the policy design stage (e.g. targets related to food security, bioenergy and hydro-power capacity additions) and at project level (such as over pumping in solar irrigation systems, water needs for biogas versus food production);
- supporting the identification and development of solutions that positively benefit multiple SDGs (such as renewable energy in local agri-food chains);
- creating better links in SDG implementation through a process that avoids the 'silo' approach (which prevailed with the Millennium Development Goals).

A WEF Nexus approach helps us to better understand the complex and dynamic interlinkages between water, energy and food

There are particularly close interlinkages between the WEF Nexus and climate change, which makes this approach especially relevant for implementing the Paris Agreement. Energy and food production are major drivers of climate change. At the same time, agriculture and water are among the most climate-vulnerable sectors.

Climate policies can improve water, energy and food security. But they can also negatively impact, or be impacted by, WEF resources. For instance, promotion of solar irrigation might lead to a reduction in CO_2 emissions but also to an unsustainable increase in demand for water. Similarly, water shortages caused by climate change might limit the possibilities to develop hydropower.

At the same time, policies and practices related to the WEF sectors – such as those

concerning climate-smart agriculture like integrated food energy systems or using wastewater to produce fertilisers or energy – can offer solutions to both climate change mitigation and adaptation.

Status, challenges and opportunities

The WEF Nexus approach is increasingly used at project level, in particular by the private sector. Large agri-food corporations are adopting the approach to reduce risks in resource availability by using them more efficiently, with lower costs as co-benefits. Major international energy companies, meanwhile, are attracted by the market potential of rural areas in developing countries that are not currently connected to the energy grid. The WEF Nexus approach helps their business case because it can boost income from food production thanks to better access to energy – and hence the ability for rural people to afford energy. In addition, a growing number of projects that call for WEF-Nexus-related proposals is creating more opportunities for small and medium enterprises.

From a technological perspective, one can note the increasing use of precision agriculture to improve input efficiency. Technology is also becoming more user-friendly and affordable. More companies are focusing their attention on water use efficiency ('use every drop of water'). Examples include making desalination energy clean, efficient and affordable, particularly in the Middle East and North Africa. The beverage industry, to take another example, is reusing and recycling water, with reduced energy bills as a co-benefit. The use of renewable energy in food chains has also gained some traction, notably the worldwide interest in solar irrigation.

In contrast to these positive developments, there are currently very few examples of 'mainstreaming' the WEF Nexus approach in developing countries' national policies, programmes and institutions. This is explained in part by the major challenge: that the WEF Nexus in reality requires multi-level and multi-stakeholder collaboration and engagement. Hence the need to consider different interests and needs, at all levels. It also requires policy coherence between WEF-related sectors. Issues that we need to address in particular include:

- what are the benefits for each WEF sector?
- what are the links between the management of WEF resources and other development sectors?
- what power differences are there between stakeholder groups and levels?
- how can we develop cross-sectoral policies and programmes?
- what is the cross-sectoral institutional set-up?

> **This approach is increasingly used at project level, in particular by the private sector**

Opportunities exist to promote the WEF Nexus approach. There are resources to support the adoption of the approach, including well-proven technologies, tools and practices. There is interest from the private sector, given the WEF Nexus approach's potential to reduce costs (for example, through energy efficiency) and secure assets (such as water).

The approach also presents opportunities for stakeholder dialogue and public awareness-raising. Moreover, there is significant potential for strong international and national support. This is because of the important enabling role of the WEF sectors and their integration in the implementation of the SDGs and the Paris Agreement – if only these can be adequately recognised. ■

SCALING UP THE APPROACH

Given the challenges in mainstreaming the use of the WEF Nexus in policies and programmes, actions to that end should adopt a stepwise process through practical approaches – rather than striving for the 'ideal'.

A key requirement is to make the case for adopting a WEF Nexus approach among policymakers and operators (technical support staff, the private sector and NGOs). This can be achieved by documenting successful WEF Nexus cases through reports, meetings and field visits.

Linked to this is the need to support existing successful WEF Nexus initiatives and fill knowledge gaps. Plugging shortfalls in information can include analysis of:

- water and energy use, needs and impacts at all stages of agri-food chains;
- environmental impacts on the use of water;
- gender considerations.

Knowledge platforms – such as the Germany/EU-funded Water, Energy & Food Security Resource Platform, the Energypedia/Powering Agriculture portal and CTCN's online knowledge platform – provide good examples of sharing nexus experience and information. They also support existing successful WEF Nexus initiatives.

Implementing WEF Nexus solutions inevitably includes considering stakeholder power and the local political economy. WEF Nexus solutions involve different types of stakeholders, at different administrative levels, and will concern key aspects of people's livelihoods and local development. Analysing those aspects and developing accountable and inclusive institutions at all relevant levels should therefore be an integral part of all WEF Nexus suggestions. This is an area where the CTCN can support through technical assistance.

Strengthening the capacity of local governments should be prioritised, as these are frontline bodies for implementing such solutions.

Progress in achieving these interventions, in particular those related to stakeholder processes and capacity-building, has been shown to strengthen such coordination in an unforced, 'organic' way.

Home-grown innovation

Endogenous solutions to climate change can offer more effective and scalable solutions, particularly in developing countries. How can we encourage more of them to flourish?

By **Ruka Sanusi**, Executive Director, Ghana Climate Innovation Centre (GCIC)

A Farmerline rep demonstrates their mobile service to a farmer in Kumasi, Ghana. The platform provides information on weather, market prices and farming advice, in their native language. Founded by Ghanaian entrepreneurs, the company aims to improve security for millions of hard to reach smallholders in Africa. © Mwangi Kirubi

There is a quote that speaks bold and loud on the Inspirational Wall at the entrance of GCIC's offices at Ashesi University in Berekuso. The quote, from TT Williams, states: "The eyes of the future are looking back at us – and they are praying for us to see beyond our own time." At the GCIC, we believe that a categorical truth of our times is that in climate change we are facing one of the world's greatest threats – a man-made disaster at a global scale.

Without exception, every country in the world is experiencing the devastating effects of climate change. According to the UN Refugee Agency, on average, 21.5 million people have been displaced by climate or weather-related events each year since 2008.

Climate change directly impacts agricultural yields, as it does the world's food security. According to the UN Environment Programme, by 2030 climate adaptation costs will range from between $140 billion and $300 billion per year. If left unchecked, climate change will reverse the progress made over the past years in development – and undermine efforts to achieve the Sustainable Development Goals.

Like many countries in Africa, Ghana is highly vulnerable to global climate change. It ranks 114 out of 181 countries in the climate vulnerability index.

Climate change is projected to affect Ghana's water resources, energy supplies, crop production and food security. The country's vulnerability is largely due to its dependence on the production of crops that are sensitive to climate change, including cassava and cocoa, and by a lack of agricultural diversification. The rapidly changing climate has dire implications for every aspect of human life.

Conventional manufacturing and consumer patterns are making our planet warmer. Our manufacturing processes involve the use of plastic, steel and cement – all of which contribute to climate change. The refrigerant inside the air-conditioning units that cool our homes and offices is a greenhouse gas. Conventional agricultural production patterns and deforestation remove the trees that pull CO_2 out of the air. When the trees are burned, they release carbon back into the atmosphere. Making and washing one pair of jeans emits the same CO_2 as driving 69 miles. These kind of manufacturing and consumer patterns beg for climate innovation and breakthroughs in what we eat, and how we live, make things, fuel our cars and power our homes.

The truth is that we can choose to at least slow down – if not reverse – the global disaster that is climate change. We can choose to make a difference – for the world won't get better if we take no action.

At GCIC, our work is at the nexus of climate change, private enterprise, and economic and ecological prosperity. We work with entrepreneurs and enterprises in the small and growing business sector across Ghana, incubating them to start, operate and grow their green enterprises with unusual intent. We proffer a different approach to commercial activity and a different premise in innovation. This is a premise that pays attention to enterprise agility. It prioritises climate-smart innovation, clean technology, circularity, and climate change adaptation and mitigation.

Endogenous solutions

Here are just some of the endogenous solutions being developed by our climate innovators.

Neat Eco Feeds: this award-winning enterprise from GCIC's 'Cohort 2' of entrepreneurs produces maggot feed for fish and poultry farmers from organic waste (faecal matter). It operates in Zebilla in the Upper East Region of Ghana. Demand for poultry in Ghana is growing by 13.9 per cent a year. However, the imported poultry sector is benefiting most from this demand, as local poultry costs four times more to produce. This is attributed to the cost of feed, which makes up about 60 to 70 per cent of the total cost of production.

The rise of fishmeal and soymeal production is causing global issues such as overfishing and deforestation. With the global population estimated to be nine billion by 2020, demand for animal protein is only set to rise. This will also increase the amount of organic waste going into landfill. So, meeting the growing demand for protein to feed farm animals requires an alternative source of protein.

Many barriers prevent the growth of climate-smart enterprises, especially for small and growing businesses

Neat Eco Feeds produces alternative protein animal feed from maggots. It uses waste sourced from Neat Meat Company Limited, which produces about 200–300 kg of waste weekly. The maggots are produced in 175 substrate tanks measuring 0.75 by 0.75 metres. Each tank goes through 10 cycles per month yielding 150 kg of waste from 50 kg of organic waste, totalling 26 tons of maggot feed every month. The products are sold to smallholder farmers in the poultry and fish farming sector. This provides them with an affordable alternative to costly protein feed such as fishmeal. Neat Eco Feeds has the potential to improve the Ghanaian fish and poultry market and become a global player that will compete with industrial global feed manufacturers.

Translight Solar is based in Accra and is one of GCIC's 'Cohort 1' businesses. The company sells solar systems to predominantly urban residential customers on a monthly lease. While the leasing or pay as you go (PAYG) model is not new, the business model has two important benefits.

First, it reduces consumer electricity wastage. Translight Solar's solution provides a facility that allows consumers to manage their energy use remotely from their cell phones – switching on certain high-energy-consuming appliances such as a washing machine during the peak hours of sunlight, and (for instance) switching off other appliances that could serve as a distraction to children when they should be doing their homework after school.

DEVELOPING ENTREPRENEURS IN COHORTS

Ghana Climate Innovation Centre (GCIC) is a pioneering business incubator, focused on developing SME ventures and entrepreneurs in Ghana's 'Green Economy'.

GCIC is part of the World Bank's infoDev Climate Technology Program, which supports high-growth, clean-tech companies to commercialise and scale innovative private sector solutions to climate change.

The centre offers seed financing, market connections, technical and business training, and policy interventions.

GCIC operates along the lines of a startup accelerator, inducting entrepreneurs in 'cohorts' and developing them together over a set time period. The culmination of the process is a competitive pitch for funding. With the cohort approach, the entrepreneurs are expected to learn from and stimulate each other's development, as well as gaining insights from a network of experts.

Low-input, floating tilapia cages in Lake Volta, Ghana. Several GCIC startups have developed ways to recover nutrients from waste to make feed for aquaculture. © WorldFish

Second, it allows Translight to switch off the electricity remotely if the customer does not pay. This reduces the risk to financiers who offer credit services to consumers to lease the solar systems.

Another of Translight Solar's key innovations lies in taking the model to larger urban homes. Currently, solar home systems supplied by PAYG companies have less than 100 W capacity, which can only power a few small appliances. Translight Solar's smallest offering uses a 1,000W panel, with the largest having a panel size of over 5,000W. This is significant for urban middle-class consumers, especially given Ghana's hot and humid weather.

BioGreen Energy manufactures and distributes a climate-smart and reliable ethanol fuel gel called Adepa EcoGel. This is an alternative cooking fuel made from molasses, sugarcane bagasse and other agro-waste. In Ghana today, over 70 per cent of households continue to use wood and charcoal as their main source of cooking fuel. This impacts not only the climate through deforestation, but also has negative effects on the health of the population. BioGreen, a company in GCIC's 'Cohort 4', is employing indigenous crops to produce a clean and efficient cooking fuel that positively impacts the climate, health and gender equality.

Allowing endogenous technologies to flourish

Endogenous solutions like these are important when considering climate action in developing countries. They can provide more effective and more scalable solutions than those adopted from elsewhere. The social, cultural and economic landscape in each country – even different regions within a country – are different. So we need to proffer responsive solutions. If Africa uses more than half of its energy in cooking fuel – mostly firewood – then we need endogenous solutions to resolve this. We expect that in Ghana at least half of climate-smart innovation and solutions will depend on home-grown technology, inputs and practices that respond to market needs.

Yet many barriers prevent the growth of climate-smart enterprises, especially for the small and growing businesses that GCIC typically serves. These barriers include market entry (start-up costs, and regulatory and administrative hurdles, for example), consumer reach (through the high price of green goods and services), socio-cultural exclusion (class, location, consumer patterns), unjust power relations (big business having more influence than SMEs), access to funding and government policy.

The drivers of transformative change are the socio-cultural norms, and the economic, financial and institutional structures that shape people's preferences, behaviours and ideals. When many of these are skewed, fractured or informed by the norms of 'business as usual', then climate action and sustainable development in the private sector (particularly for SMEs) is slowed. This means that, in turn, green growth is slowed. Then we become more vulnerable to the vagaries of climate change inaction. ■

Planting gnetum in the Lekie Province, Cameroon. The leaves of the vine are used in food and medicine, and play an important role in reducing anaemia.

Forests as assets

The destruction of forests for short-term economic gain is perhaps the most visible sign of humans' contribution to climate change. We must reassess forests' value, harnessing technology to reverse the damage we have wrought.

By **Susan C. Gardner**, Director, Ecosystems Division, UN Environment Programme (UNEP)

Forests are unique assets. Like humans' collective knowledge, they do not depreciate over time. In fact, the classical definition of an economic asset applies to forests: a resource with value for a corporation or an individual, or something that can provide current and future benefits. However, it is the nature of these current and future benefits – their richness and irreplaceability – that makes forests unique and challenging to quantify using the standard economic toolkit.

If an asset is a resource with value, then what does value mean in the context of forests? Forests are usually cut for logging and burned down to make room for agriculture. Lost in these uses are the constellation of carbon and non-carbon benefits that forests provide.

The value of a forest goes well beyond its value as a stream of income from logging or agricultural conversion. It is a tremendous loss for a fraction of the benefits. Cutting forests as we do today is like selling Google for the value of its data centres.

Contributions to climate change

Forests are key to attaining climate change mitigation goals by 2030. UNEP's *Emissions Gap Report 2017* tells us that current targets to cut greenhouse gas emissions significantly fail to match the severity of the climate crisis. Even with tremendous political will, a world powered by renewable energy will not materialise overnight. We have a long way to go.

How can we facilitate the transition? An important part of the answer lies in forest ecosystems. Reducing emissions and removing massive amounts of carbon from the atmosphere through halting forest loss and restoring forests have a mitigation potential of around 5.3 GtCO2e/year by 2030 – almost a quarter of the estimated emissions reductions required to get on to a 1.5˚C target pathway. This figure could double if afforestation, agroforestry and

carbon sequestration in soils were taken into account.

Forests are under threat because of our failure as a society to reflect their true value in our daily decisions. Last year, we lost 3.6 million hectares of pristine tropical forests, the size of Belgium. This figure increases threefold if we include both primary (untouched by humankind) and secondary (already disturbed or logged) forests.

So, what technologies do we have to help correct the situation?

Remote sensing technology for forest monitoring

The capacity to remotely monitor land use change has undergone nothing less than a revolution in the past 10 years. When the UN-REDD Programme started supporting countries in establishing forest monitoring systems, observers could only identify forests. Now, with advances in remote sensing technology, individual trees can be seen. And with the cost of remote sensing technology falling, this high-resolution monitoring is becoming the new normal.

The advances in remote sensing have now gone beyond measuring land use changes to also including carbon content. Today, the combination of LiDAR (light detection and ranging) technologies and satellite imagery can produce 3D carbon maps showing the amount of carbon above soil. Soon, it will be possible to compare nationwide 3D images of above-soil carbon to estimate net carbon gains and losses over time. Together with images of forest cover and adding the price of forest carbon, you could rapidly estimate REDD+ payments not only from avoided deforestation, but also from forest restoration and enhancement of carbon stocks.

Drone technology

Advances in satellite imagery have occurred simultaneously with advances in drone technology. The availability of improved batteries and lighter materials has made drones affordable and available to the wider public. They have been rapidly put to good use for forest monitoring and management.

Drone equipment and software exists that can scan forests, identify which trees are best placed for selective logging and automatically calculate expected volume. Because the handling of equipment and software does not require highly specialised knowledge, it facilitates the management of forests in situations where forestry professionals are in short supply. For example, the UN-REDD Programme has provided equipment and training to indigenous communities that are now able to monitor and manage large tracts of their ancestral forest areas with the help of drone technology.

Remote early fire detection systems

Advances in remote sensing and drone technology have, in turn, permitted corresponding advances in early fire detection systems. This is important because climate change is making forests more vulnerable to fires.

Systems under development now include networks of infrared cameras and heat sensors that can spot wildfires before they become too difficult to control. These can be connected to command centres that also receive data from satellite imagery. Drones can be deployed to accurately assess the extent and position of forest fires and plan responses accordingly. Some of these systems can automatically trigger response actions, like the deployment of fire brigades and hydrant planes.

Logging traceability

Technology for tracing logging products has been in use for some time, but its penetration is low. The most common approach is to assign barcodes to each log. However, barcodes open possibilities for tampering, and therefore allow illegal logging products to mix with legal ones. So, why not use the equivalent of a tree fingerprint? There is now scanning technology that can identify the unique pattern of tree rings and track movement from the moment a tree is cut down all the way to its final use.

Participatory landscape management

This is one of the most cost-effective technologies for forest conservation and sustainable use. Most forests under threat comprise a mosaic of ownership and uses. This requires stakeholders to come together to decide on land management options in a collaborative way to accommodate for activities like preserving protected areas, maintaining biological corridors, allowing forest extraction, agriculture and tourism, among others. In this context, gender based access to forest rights, ownership and decision-making should also be considered – a major area of expertise at CTCN.

Participatory landscape management, when done well, is more of an art than a technique. While it may not seem as exciting as drone or remote sensing technology, it provides the foundation to make these technologies effective.

This is an important lesson: successful conservation and sustainable forest management will for the foreseeable future continue to depend on 'soft' actions, like reaching consensus on resource use and an equitable distribution of its benefits. ■

CTCN IN COSTA RICA

Technical assistance to inform forest conservation

In Costa Rica, the role of forests in climate change adaptation and mitigation is widely acknowledged. However, when it comes to the management of forests and associated ecosystem services, there is a lack of access to information for improving the decision-making process.

CTCN is offering technical assistance with the design of a data and information management system for managing tropical forests to support climate change mitigation and adaptation, in addition to financial mechanisms for ecosystem services.

The development of effective and feasible IT tools will provide quick and efficient access to information and catalyse processes for decision-making and strategy design.

It is expected that this will increase Costa Rica's capacity to manage forests and conserve ecosystems.

Moving to a circular economy in Latin America

Latin America should make green economics a central strategy to mitigate the threats to its unique natural resources.

By **Giovanni Calderón Bassi**, Director Ejecutivo Agencia de Sustentabilidad y Cambio Climático (Executive Agency for Sustainability and Climate Change, Chile)

Latin America, with its common history and for the most part shared language, is frequently considered as a whole. As such, it would rank as the world's fourth-largest economy and be responsible for about 11 per cent of global greenhouse gas (GHG) emissions. However, economically, the region is far from homogenous and should be addressed on a country-by-country basis.

The most developed economies in the region are Chile, Uruguay and Argentina, with GDPs per capita between $20,000 and $23,000. These countries have a consistent ranking in terms of the Human Development Index, being classified as 'very high human development' – and Chile and Uruguay have been classed as high-income economies by the World Bank since 2013. But in terms of contribution to global GHG emissions, these countries make a quite limited contribution: Chile 0.23 per cent, Uruguay 0.08 per cent and Argentina 0.74 per cent.

Extreme vulnerability to climate change is the feature that unifies the region and makes it a global priority. As a region, there is a common imperative for international climate agreements to recognise its geographic and climate situation, its demography and socioeconomics, and its high sensitivity to natural assets – it has a remarkable richness of biodiversity and forests, which are an asset to the rest of the world.

This vulnerability is already manifesting itself in economic performance and the Economic Commission for Latin America and the Caribbean (ECLAC) estimates that the economic cost of climate change in Latin America and the Caribbean will be between 1.5 per cent and 5 per cent of GDP by 2050.

Climate change is restricting existing patterns of production and consumption, and demands radical change in response. If we ignore these demands, our economic development and social progress will stall.

Regional approach

The imbalance between contribution towards climate change and the damage experienced from it is a phenomenon shared by most countries in the region and it calls for a regional approach. The countries of Latin America need to work together to design public policies;

CTCN TECHNICAL ASSISTANCE

The circular economy is an industrial model that is restorative by design and proposes that, instead of extracting natural resources, materials that have already been processed can be recovered and reused in various ways, thus protecting natural resources from over-exploitation – an issue that is particularly sensitive in Latin America.

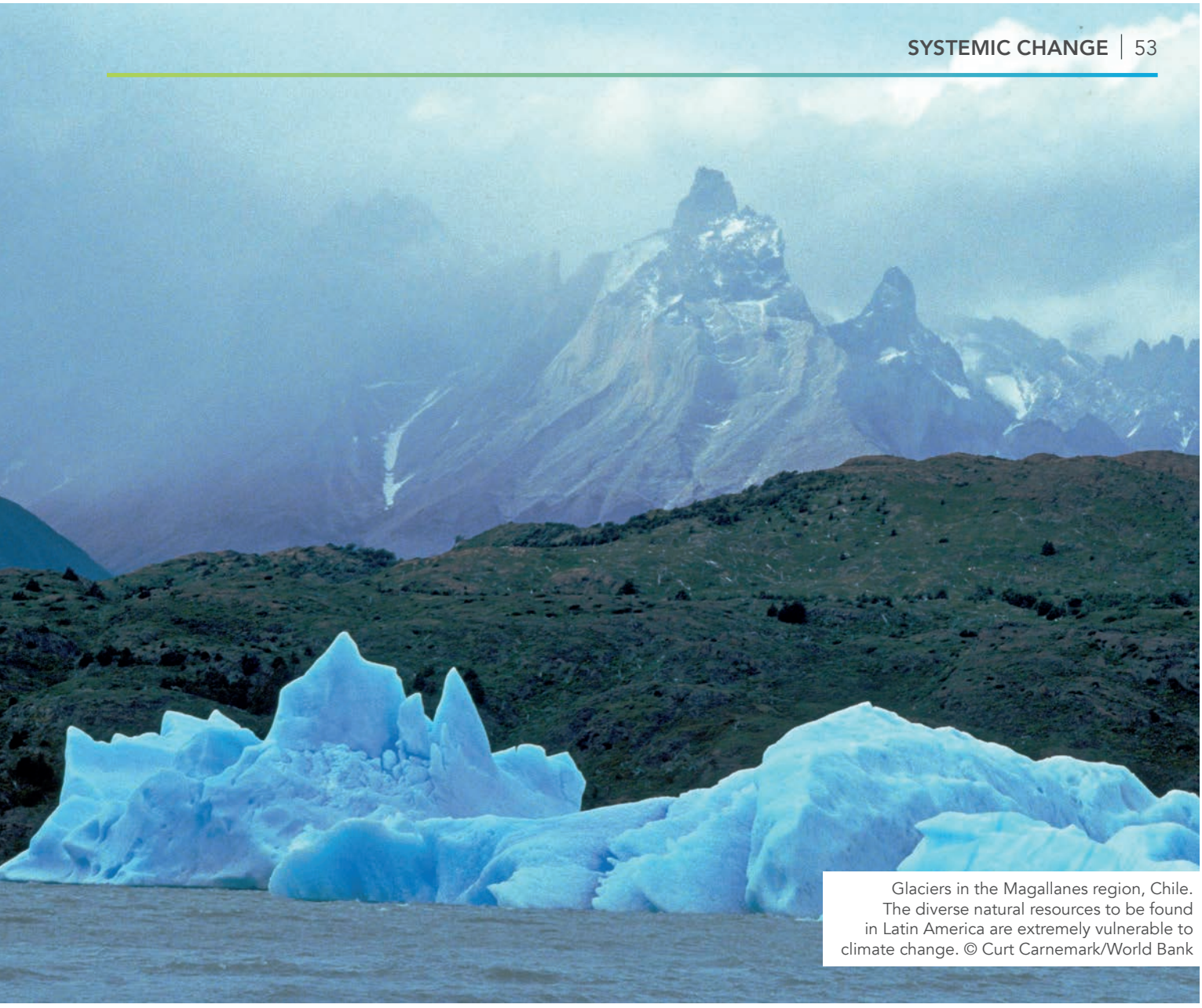
The objective is to keep scarce, valuable resources in circulation for longer periods of time, promoting recycling and avoiding loss of materials. Achieving these objectives requires alternative models of business such as reuse, remanufacturing and product-as-service.

CTCN support

The CTCN is performing an assessment of the circular economy in Brazil, Chile, Mexico and Uruguay in order to prepare a road map for each country. These will reveal who are the key actors/interested parties and will characterise gaps and deficits. The roadmaps will then serve as a management tool for the future implementation phase.

Expected impact

- reduced use of resources needed per unit produced;
- reduction of the quantity of waste produced;
- reduction of the quantity of energy consumed. Reuse of raw materials reduces the amount of energy required to obtain an element that can be re-used in preparing the same or another product;
- development of new businesses and generation of new job positions. Latin America presently has a low rate of recycling and increasing the present rate will create the need to hire more personnel for the various tasks required in the different links of the value chain of each product prepared;
- promotion of innovation, because it is necessary to change the production model and update the production infrastructure, equipment and technologies, to process what is today considered waste (future raw material);
- mitigation of and adaptation to climate change.



Glaciers in the Magallanes region, Chile. The diverse natural resources to be found in Latin America are extremely vulnerable to climate change. © Curt Carnemark/World Bank

there needs to be coordination between governments and non-state actors; and action on climate mitigation and adaptation needs to be integrated.

Faced with the threats posed by climate change, the concept of a circular economy has much to offer in the region. In part, it will help to conserve an environment already under attack. As an example, the region currently produces 231 million tonnes of solid waste per year, of which only 4.5 per cent is recycled. Almost 70 per cent is disposed of in some sort of landfill, while more than a quarter ends up in open dumps.

The move towards a circular economy would benefit the workforce and the economy, as much as it does the environment. It would create opportunities for innovation and entrepreneurs, new technology and quality jobs, and bolster the fight against climate change. Research for other regions has suggested that massive economic gains are to be had. A report issued by the Ellen MacArthur Foundation and the McKinsey Center for Business and Environment demonstrated that a circular economy approach could boost Europe's resource productivity by 3 per cent by 2030, generating cost savings of €600 billion a year and €1.8 trillion more in other economic benefits.

Reinforcing the Rulebook

Climate action should be viewed as a subset of the Sustainable Development Goals. The process of transitioning to a green economy, reducing emissions and waste, and using resources more efficiently must be done with the goal of improving the welfare of society. If we fail to follow this path, we will be left behind as economies and societies.

Another factor that needs to be addressed is accountability for consumption. As the fossil-fuel economy developed, the complex web of trade that was created means that the location of production, and the consequential GHG emissions, can be far removed from the consumer, who should be held responsible for the emissions.

This highlights the importance of reinforcing the Paris Agreement Rulebook. The Rulebook must act as a robust mechanism that will support the development of a transparent and efficient carbon market. There needs to be visibility and fairness if the planet is going to be able to achieve carbon neutrality in the timescale recommended by the IPCC. The case for a circular economy in Latin America is already persuasive but the backing of a strong international legal framework should dispel any excuses for not embarking now. ■

Garment workers in Kandal province, Cambodia, travelling on a 'romork'. © Chhor Sokunthea/World Bank

Towards climate-smart transport in Cambodia

The need to curb emissions and the threats of climate change are shaping Cambodia's plans to expand access to mobility and transport.

By **Hak Mao**, Director, Department of Science and Technology, The General Secretariat of the National Council for Sustainable Development, Cambodia

In recent years, Cambodia's transport infrastructure has been restored and extended across almost the entire country.

The number of registered vehicles has more than doubled from 215,468 in 2008 to 441,800 in 2017. On the railways, a new passenger train service started operating in 2016, while the volume of freight transport increased about 10 times between 2013 and 2017. Rail traffic is expected to grow by between 7 and 12 per cent a year between now and 2030, according to projections by the Asian Development Bank.

Cambodia's inland waterways – comprising around 1,750km, of which 580km are navigable all year round – have been in steady decline as cargo switched to road transport. But thanks to improvements across the network, including dredging and providing safety markers, the tide is once again turning in waterways' favour. The amount of cargo and number of vessels are on the rise and are predicted to increase in the future.

Air transportation, meanwhile – both of passengers and freight – has increased significantly over the last decade. The Cambodian government set a policy to attract seven million foreign tourists annually by 2020. To facilitate this, Cambodia is improving both its international airports and local airports in several tourist-destination provinces.

Climate change impacts

Cambodia is facing increasing threats from climate change. Average temperatures have risen and the trend is set to continue, with mean temperatures predicted to increase by between 0.013˚C and 0.036˚C per year by 2099. Flooding has caused death, destruction of crops and livestock, and damage to homes and the already fragile network of community infrastructure such as schools and health centres.

The country's Ministry of Public Works and Transport reported that, in 2011, 16 out of 24 provinces and municipalities were inundated with flooding and over 1.5 million people affected. Flooding damaged 186 national and provincial roads stretching

more than 718km, as well as 20 bridges. The impacts of climate change are predicted to slow average GDP growth between 2017 and 2050 and reduce absolute GDP by 0.4 per cent in 2030, 2.5 per cent in 2030 and 9.8 per cent in 2050 (compared to what GDP would have been without climate change).

Greenhouse gas (GHG) emissions from the transport sector

Globally, the transport sector is the second largest in terms of CO_2 emissions, contributing about a quarter of total CO_2 in 2017, according to the International Energy Agency (IEA). The IEA also estimates that transport accounted for half of the total oil demand in Southeast Asia in 2015, and will account for 53 per cent by 2040. Across the region, IEA figures show that road vehicles account for 28 per cent of total energy-related CO_2 emissions, and approximately 92 per cent of transport-related CO_2.

Focusing on Cambodia, the country is not currently a significant contributor to GHG emissions. In 2000, per-capita GHG emissions were about 0.23 tCO_2e. However, this figure is projected to rise to about 1.10 tCO_2e by 2030 and 5.49 tCO_2e by 2050. Transport already contributes more than any other sector to Cambodia's CO_2, and this is projected to continue. By 2050, transport CO_2 is predicted to rise to 10,816 $GgCO_2e$ (see table).

Reducing Cambodia's transport emissions

In 2013, Cambodia approved its technology needs assessment action plan. This identified three technologies for reducing transport-related emissions. These were: energy-efficient urban mass transport; vehicle emission standards; electric motorbikes and bicycles. The plan indicated that an energy-efficient urban mass transport system would not only reduce GHG emissions, but would also alleviate traffic congestion and improve the quality of the local environment.

In addition, the Phnom Penh Capital Administration developed the Phnom Penh Urban Transport Master Plan 2035 to solve the current transport problems. The plan was designed to shift from a private-oriented urban transport system to a well-balanced system of public and private transport. It envisaged a combination of road, public transport and traffic management improvements to enhance the mobility of citizens, and to enable Phnom Penh City to fulfil its potential.

Meanwhile, the Cambodia Climate Change Strategic Plan 2014–2023 aims to develop the country towards becoming a green, low-carbon, climate-resilient, equitable, sustainable and knowledge-based society. Cambodia indicated in its intended Nationally Determined Contribution that it is expected to cut emissions across the economy by up to 3,100 $GgCO_2e$ (27 per cent) by 2030 compared with 'business as usual'. Priority actions in the transport sector were to promote mass public transport, to improve the operation and maintenance of vehicles through vehicle inspection and eco-driving (optimising fuel consumption), and to increase the use of hybrid cars, electric vehicles and bicycles.

The projected combined effect of these transport actions would be to cut GHG emissions by 390 $GgCO_2e$ by 2030.

International cooperation

Cambodia has received support for tackling climate change from a wide range of international organisations and development partners. These include the Asian Development Bank, the International Fund for Agricultural Development, the World Bank, the Swedish International Development Cooperation Agency (Sida), the EU, the United Nations Development Programme (UNDP) and the World Health Organization.

The Cambodia Climate Change Alliance – funded by the EU, UNDP, Sida and the Danish International Development Agency – has been designed to strengthen and fulfil its mandate to address climate change and to enable line ministries and civil-society organisations to implement priority climate change actions. The country has also requested support for low-emission mobility from the Climate Technology Centre and Network (CTCN).

The Royal Government of Cambodia has also been implementing the Strategic Programme for Climate Resilience (SPCR) with financial support from Climate Investment Funds. The SPCR covers two streams. The first is to build knowledge about climate change impacts on Cambodia and how to mainstream climate resilience into agriculture, water resources, transport and urban infrastructure. The second is to invest in applying new skills, techniques, technology and engineering practices for climate resilience.

Cambodia still needs more support to address climate change impacts. Therefore, the government is mobilising support and cooperation from development partners, donor countries and other stakeholders to ensure the country can achieve sustainable development. ■

THE TREND OF GHG EMISSIONS IN CAMBODIA

Sector/year	2000	2010	2030	2050	2030/ 2010	2050/ 2010
Residential	948	936	1,287	1,890	1.4	2.02
Commercial	68	142	311	682	2.2	4.80
Energy industry	385	1,453	3,539	8,888	2.4	6.12
Manufacturing	320	689	1,144	1,766	1.7	2.56
Transport	709	2,000	4,631	10,816	2.3	5.41
AFOLU*	(8,882)	15,689	25,504	34,112	1.6	2.17
TOTAL $MtCO_2eq$	**(6,452)**	**20,909**	**36,416**	**58,154**	**1.7**	**2.78**

Source: GSSD (2015) *Agriculture, Forestry and Other Land Use

The sustainability of city growth

As populations grow and concentrate in cities, the risk and scale of climate disasters is intensified. We must make cities and infrastructure climate-friendly in construction – and resilient to extreme events.

By **Maimunah Mohd Sharif**, Executive Director, UN-Habitat

Today, the world's cities face many interconnected environmental, social and demographic challenges. These challenges have been caused by economic growth, human development, increasingly rapid urbanisation and climate change. More than half of the world's population lives in cities, and this is likely to increase to 70 per cent by 2030.

The anticipated growth in urban populations will require extensive construction and reconstruction of urban infrastructure and buildings. On average, urban land cover is expanding at twice the rate of urban population growth. At face value, this level of urban expansion seems worrying. Yet it could also be the catalyst for adopting new technologies to construct buildings and infrastructure with low or near-zero emissions that are adapted to climate change.

Early action in this area is important and cost-effective: the long service life of infrastructure and buildings makes them prone to energy and emissions 'lock-ins' that are more expensive to change.

For example, buildings account for one third of global energy consumption. Buildings would have to cut their emissions by over 80 per cent compared with 2010 levels to achieve a pathway consistent with 1.5˚C of warming above pre-industrial levels. The uptake of renewable energy sources, low-emission technology and energy-efficient appliances in cities can reduce emissions drastically, as can reduced energy use in buildings or transport. Urban policymakers – along with residents and other local stakeholders – are therefore at the forefront of efforts to avoid global warming of more than 1.5˚C.

Sustainable urban development

In 2015, the United Nations adopted the 2030 Agenda for Sustainable Development. This laid out 17 Sustainable Development Goals (SDGs) for national and local governments to achieve and report on. The SDGs seek to end poverty, protect the environment and ensure that all people enjoy peace and prosperity. The imperative of sustainable urban development is captured in SDG 11: "make cities and human settlements inclusive, safe, resilient and sustainable". The interconnected nature of SDG 11 thus means it functions like a hub for all the other SDGs.

The New Urban Agenda, adopted in 2016 at the Habitat III conference, provides a roadmap to achieve SDG 11, as well as the urban dimensions of other SDGs. The Agenda promotes the wellbeing of urban residents, enhancing cities' economic competitiveness, and safeguarding the environment. Cities lie at the core of the sustainable development agenda globally. Local leaders and policymakers have to work hand in hand with private-sector partners, urban planners, industry leaders, educational institutions, citizens and civil society to achieve the Agenda's vision for a better and more sustainable future.

One of the biggest challenges of rapid urbanisation is that much of the urban growth in developing countries occurs spontaneously, not following official planning frameworks. As a result, large numbers of urban residents live in informal settlements that are vulnerable to natural and man-made hazards.

Climate change has also increased the frequency and intensity of natural hazards, affecting millions of urban dwellers. Most houses in informal settlements are poorly built and are more liable to collapse when hit by storms or floods. Many informal settlements develop on dangerous sites – for instance, flood plains, coastlines or unstable slopes – because housing on safer sites is too expensive.

The end result is that the urban poor, often living in fragile locations with no risk-

Informal settlements in West Point, Monrovia, Liberia. Informal settlements present the greatest challenge of rapid urbanisation: poorly constructed and located in the most vulnerable situations. © Albert Gonzalez Farran/UN Photo

The urban poor, often living in fragile locations with no risk-reducing infrastructure, bear the brunt of these intensified climate threats

reducing infrastructure such as functioning storm drains, bear the brunt of these intensified climate threats.

High levels of poverty and illiteracy mean that these communities have limited capacity to deal with climate change impacts. In addition, the political and institutional marginalisation of these communities, stemming from non-recognition of informal settlements as part of the larger city fabric, often results in the absence of meaningful risk-reducing services and infrastructure.

The United Nations Human Settlements Programme (UN-Habitat) has developed knowledge, programmes and tools to address the challenges that climate change poses to cities and, particularly, the urban poor. On both climate change adaptation and mitigation, UN-Habitat has developed a range of technology solutions, methods and practices that are low cost and resource efficient. These include:

- **Early-warning systems (EWS):** These involve technology and associated policies and procedures designed to predict and mitigate the harm of natural and human-initiated disasters and other undesirable events. These include floods, earthquakes, avalanches, tsunamis, tornadoes, landslides and drought. In Myanmar, through the Myanmar Climate Change Alliance, UN-Habitat and UNEP developed an EWS that increases public access to weather and climate-related forecasts around the clock. In Fiji, UN-Habitat has initiated a similar process.
- **Fukuoka method:** This is a semi-aerobic landfill design that speeds up

the decomposition of waste materials, improves the quality of water draining from the site and reduces methane gas, one of the most potent greenhouse gases (GHGs). This, in turn, reduces the future risk of fire and lengthens the life of the landfill site. Fukuoka University in Japan developed the method in collaboration with UN-Habitat. UN-Habitat has implemented this technology in many cities around the world, including in Kenya, Ethiopia, Myanmar and China. In Addis Ababa, this project has benefited over a million residents.

- **Building technologies:** When building or upgrading houses, there are opportunities for design and technology to produce climate mitigation and cost benefits. Designs that maximise natural ventilation reduce the need for cooling systems. Those that maximise natural light inside the property can reduce energy demands for lighting. Green roofs and walls can help with temperature regulation in extreme heat – and can also generate food if appropriate plants are grown. A loft can provide a layer of insulation under the roof and serve as a storage space for valuables during flooding. Roofs that are solid enough to take solar panels can also enable household-level electricity generation. UN-Habitat's publication *Sustainable Building Design for Tropical Climates* offers specific solutions to countries in the developing world that can benefit from resource-efficient building designs and practices in tropical and changing climates. In Pakistan, UN-Habitat supported the national government to formulate guidelines for green building codes as a first step towards promoting sustainable consumption and production. In Myanmar, UN-Habitat supported the formulation of the Myanmar National Building Code.
- **Low-emission development strategies (LEDS):** UN-Habitat has worked in over 60 cities in eight countries to accelerate the low-emission development process. In Rwanda, average temperatures have increased by 1.4˚C since the 1970s. At current rates, this will rise to 2.5˚C by 2050, according to government estimates. Projected climate risks include intense rainfall events, increased risk of flooding, landslides and soil erosion. Climate change has therefore been recognised as a risk at the highest political level while also being seen as an economic development opportunity. Thus, one of the activities that UN-Habitat developed under the Urban LEDS programme in Rwanda was to produce local-level GHG inventories for three cities. This helped those cities to understand sources of pollution and to better promote energy-efficient technologies in infrastructure development.
- **City Resilience Action Planning:** UN-Habitat has implemented its City Resilience Action Planning (CityRAP) tool in over 24 cities globally. For example, in Sri Lanka, eight cities were supported to integrate disaster risk reduction plans into city planning. The CityRAP is designed for local governments and other institutions to mainstream resilience into their existing and future policies, plans, budgets, institutional set-ups and actions. This puts local governments and urban stakeholders in the driving seat in urban resilience planning. The key features of the tool include local ownership and engagement, flexibility and adaptability to different realities, and mainstreaming local knowledge and solutions.
- **Participatory mapping for upgrading informal settlements:** Through a detailed diagnosis, UN-Habitat has developed a city-wide strategy for Kigali in Rwanda. The strategy seeks to upgrade under-serviced and unplanned settlements to achieve positive socio-economic impacts and to counterbalance socio-territorial segregation trends. This includes an in-depth analysis of Kigali's population, international agreements, the Kigali Master Plan, as well as the topographical features of the city. It therefore assesses the environmental risk that low-income citizens are exposed to. The strategy proposes concrete interventions, such as constructing key service infrastructure and land readjustment, that reduce the environmental risks associated with climate change, including landslides and floods.
- **Sustainable Urban Pathways:** Together with UN Environment and the Wuppertal Institute, UN-Habitat embarked on a four-year project aimed at assisting four countries (initially) in making progress against the SDGs, the New Urban Agenda and the Paris Agreement through low-carbon basic services. Examples of current pilot projects include electric bike-sharing in Belo Horizonte, Brazil; electric tuk tuks for Kochi, India; and developing an eco-district in Quito, Ecuador.

UN-Habitat has worked in over 60 cities in eight countries to accelerate the low-emission development process

For UN-Habitat, it is extremely important to focus on the developing world and its most vulnerable populations when designing and implementing technological solutions that support communities around climate adaptation and mitigation. UN-Habitat focuses on simple tools and practices that can generate substantial benefits: an increase in technology use in previously underserved communities; an increased technological understanding through local capacity-building efforts; and overall smarter and more efficient community practices.

UN-Habitat works closely with local, regional and national governments on localising international climate targets and sharing good practices and solutions, equipped to shape their country's future. This is the key to the success of any initiative, anywhere in the world. ■

Guarding the coasts

Coasts, particularly in the developing world, are in the firing line of climate change. What actions must we take now to protect the vulnerable communities whose lives depend on them?

By **Joyashree Roy**, Bangabandhu Chair Professor, Asian Institute of Technology, **Sabuj Kumar Mandal**, Assistant Professor, Indian Institute of Technology Madras, **Sheikh Tawhidul Islam**, Professor and Director, Institute of Remote Sensing, Jahangirnagar University, **Satabdi Datta**, Environmental Economist, The Celestial Earth, **Indrajit Pal**, Assistant Professor and Chair, Disaster Preparedness, Asian Institute of Technology, **A. Saleem Khan**, Postdoctoral Fellow, Indian Institute of Technology Madras

Repairing an embankment after a cyclonic tidal surge in Bagerhat district, Bangladesh. South Asia, characterised by high population and poverty, has comparatively little capacity to adapt to climate change. © Xinhua/Alamy

Scientific assessment by the Intergovernmental Panel on Climate Change (IPCC) states with high confidence that even if we limit global warming to 1.5°C above pre-industrial levels, sea levels will continue to rise well beyond 2100. Particularly vulnerable are the world's coasts.

The World Economic Forum's *Global Risks Report 2019* shows that around 90 per cent of all coastal areas will be affected by climate change to varying degrees. Coasts will suffer more than other areas from the effects of warmer ocean temperatures, increased acidification, more frequent and intense storms, more cyclones, and rises in precipitation. These factors will in turn lead to rising saltwater intrusion, coastal flooding, damage to infrastructure, and increasing uncertainty about the livelihoods of people dependent on coastal resources.

The growth of the nascent 'blue economy' – using ocean resources sustainably for economic growth and improved livelihoods while preserving the ocean ecosystem – offers opportunities for new mitigation strategies to help coasts. Coastal management that mitigates the effects of climate change must be put into practice now to minimise the need for drastic adaptation in the future.

This raises two key questions: first, how do we manage historic interventions in coastlines that were made without regard to climate change, if we are to minimise the risks to lives and economic wealth? Second, what can we do differently to avoid future risks? Any practical solutions will need more intensive research, as well as planning and

design that focuses on and involves local communities.

Threats, risks and responses

Coasts are important places for human settlements, economic infrastructure and social recreation. They accommodate about 10 per cent of the world's population and are gateways for about 90 per cent of world freight trade, through elaborate coastal shipping infrastructure. Nearly half of the world's major cities are located within 50 kilometres of a coast. Coastal population densities are 2.6 times greater than those of inland areas, and have seen an exponential rise.

The migration of coastal communities reflects the unendurable challenges they currently face. Compounding the climate threats is the fact that coastal communities tend to include relatively high proportions of poor and marginalised people. At the same time, developing countries – especially those in South Asia with high population density and poverty – have comparatively little capacity to adapt, given the speed with which climate change is taking place.

The social groups most impacted are fishing communities, farmers, harvesters of natural resources from mangrove forests, such as honey, golpata (nipa palm) and shrimp in Bangladesh, and communities dependent on the downstream value chain of coastal resources. In disaster-prone coasts, the male members of the communities often migrate to protect their livelihoods, leaving the women and children behind.

Climate models predict risks to various economic activities. Policymakers see climate risks through the lens of politics and regional justice. But coastal communities perceive the risk differently. To strategise action to help coastal communities, we must identify and map the risk categories of the local physical infrastructure. These include energy supply, trade and social recreation, as well as other economic functions and processes.

Bangladesh's contribution to global greenhouse gas (GHG) emissions is less than 0.35 per cent, but the country faces a potentially catastrophic level of climate impacts. National documents suggest that taking either no or limited global climate action would cause the country to lose 2 per cent of its GDP by 2050 and 9.4 per cent by 2100. This would lead to more poverty-ridden conditions and the displacement of millions of people. Many other developing countries face a similarly bleak outlook, leading to calls for 'climate justice' in climate negotiations.

At the global scale, recognising the limits of adaptation in local contexts and strengthening mitigation action is of primary need. Unlike disaster management adaptation, climate response must be proactive rather than reactive. Scenario-based backcasting – working backwards from a desired future outcome to identify actions needed now – can help us understand adaptation needs over time. This can inform adaptation project design to give viable protection against future threats.

> **Unlike disaster management adaptation, climate response must be proactive rather than reactive**

Participatory rural appraisal methods must take into account context, culture, knowledge, agency and the preferences of communities. Best practice is when both the approaches are complementary in response design.

State and non-state actors have the power to enhance the adaptive capacity of the private sector by providing a range of public goods and services. These include:

- early-warning systems for extreme weather events;
- installation of GPS in deep-sea fishing trawlers;
- developing climate change-responsive physical and financial infrastructure;
- improving access of households to loan finance;
- building disaster shelters;
- organising efforts to move people to safe places during disasters;
- building embankments and flood-protection infrastructure;
- coastal plantation schemes;
- water supply projects;
- improving drainage systems in coastal cities; and
- dredging and restoring coastal rivers and canals.

CTCN ASSISTANCE IN BANGLADESH'S COASTAL AREAS

Being vulnerable to regular water and climate-induced disasters such as cyclones, storm surges, floods, droughts and inundation by saline water, the threat of climate change looms large in Bangladesh, affecting the economy and livelihoods.

It is essential to put in place appropriate technical measures to monitor the changes due to climate change. There is not a single offshore platform along the coast of Bangladesh to regularly monitor actual sea-level rise over time.

Measuring water and soil salinity requires technological inputs and updating. The impact of climate change on different sectors needs to be studied in depth over time and space.

Objectives

- Use of satellite imagery for periodic monitoring and impact assessment.
- Setting/linking up with offshore mechanism to monitor the sea-level rise.
- Development of analytical model(s) for impact assessment using satellite and sea-level rise data.
- Sea-level processing software for analysing data.
- Application of tools/software developed or identified for demonstration purposes in one of the coastal areas.
- Establish in-country capacity building and training that can be institutionalised.

In developing countries especially, individuals with higher income and savings, who own a range of assets, or who enjoy more mobility, education and social connection are likely to be much better adapted to the effects of climate change. Yet, governance, the state of natural capital, the existence of social capital and enabling government regulations can all have considerable influence on the adaptive capacity of a community and households.

Hurdles for developing countries

Knowledge about climate adaptation and mitigation currently cannot keep up with the frequency and intensity of extreme climate-related events that coastal communities in developing countries now face.

In Myanmar, for example, there is no time for coasts to recover or for communities to take appropriate action. This leads to inappropriate solutions being implemented quickly: old-fashioned projects that have marginal impacts, rather than effective long-term solutions.

The lack of widespread technical capacity, lack of funding, inadequate institutional mechanisms for coordinated actions, conflicting views on priorities, and the limited capacities of vulnerable, affected communities all impede long-term adaptation strategies by subsuming climate change adaptation into the objectives of development projects.

Too much focus is on city-scale actions in countries where 60 to 80 per cent of the population live in rural areas. These lead to too little attention given to marginalised rural communities and the trivialising of climate change issues. CTCN's project 'Promoting data for climate change, drought and flood management in Myanmar' should help focus action where it is needed most.

In policy design, functional needs are translated into functional requirements through first-hand knowledge and a deeper understanding of extreme climate events. If policy-making becomes institutionalised and detached from projects in the field, the science–policy connection is weakened, leading to uninformed policy design at the local level. It also leads to a lack of vertical integration with national and regional action plans. Climate adaptation needs to be scientifically embedded in educational programmes and into integrated coastal zone management.

A wide variety of evidence – global assessment reports, national policy documents, interviews with government officials and village focus group discussions in various countries – shows that some regulatory mechanisms are rejected by local communities and associations due to a lack of adequate consultation or trust among the various stakeholders.

The regulatory bodies consider these as barriers to policies they wish to enact – like a ban on deep-sea fishing during fish breeding period, a ban on gill nets in fishing, or providing training facilities for fishermen. Some communities report regulatory-level corruption such as in the implementation and violation of laws in the coastal regulation zone.

This erosion of trust is leading to dysfunctionality. Educational institutions engaged in human capital-building can play an important role, but the disconnection of science policy is a major barrier towards achieving that.

Conclusion

Adaptation depends greatly on the adaptive capacity or adaptability of an affected system, region or community to cope with the impacts and risks of climate change. This calls for systemic change, where technology, institutions, education and behavioural changes can all play a connected role. International institutions can help bridge the gap between science and policy by strengthening local institutions and initiating a platform for science–policy dialogue.

Experience from multiple examples shows that various measures can speed up knowledge dissemination. These include an international coastal education and research network, a task force, connecting educational institutions, a joint research agenda and training for policymakers. These can also help create demand from local communities for climate action.

Documenting and sharing best practices and processes from various country contexts is a major source of knowledge support. This can avoid many aspects of maladaptation and also strengthen adaptation–mitigation synergies. For the coastal sector, the success factors that will increase the resilience of the coastal ecosystem and people include the cooperation of a broad range of stakeholders who pursue individual goals from using coastal ecosystem services. However, communication, knowledge-sharing, outreach, capacity development and networking are all critical for developing countries. Here, international networks like CTCN can help. Now, within the context of the blue economy discourse and ocean mitigation, we need strong international cooperation.

We also need in-country capacity. Coastal countries living with the realities of climate change understand best how to craft resilience-building adaptation projects that are suitable in their physical, ecological, social, cultural and economic contexts. Provisions for periodic review of national and subnational policies are absent in the current practices of developing countries.

Developing instruments for designing adaptation programmes, monitoring and reporting could also help countries to create adaptation projects/plans that are effective, efficient, sustainable and harmonious. Identifying appropriate technologies for sectors like water, energy and agriculture – as well as the transfer of these technologies – will be crucial for making coastal communities resilient to climate change threats.

Many studies from developing countries show that a lack of sufficient policy actions for human and social capital development, nature-based adaptation measures, asymmetry in information, and participatory decision-making happen due to a lack of understanding about the predicted widespread impact of climate change.

In addition, there is a need to generate actionable regional scientific knowledge through collaborative partnerships among scientists, policymakers, practitioners and institutions.

Such collaboration among different scientific bodies and policymakers can be done through developing joint production of assessments by experts and decision-makers. We need a better integration of different viewpoints, by encouraging networking, co-production of knowledge, and a stronger role for academia at the national level. ■

Case study:

Tackling flooding in Jakarta

A Climate Technology Centre and Network (CTCN) project to develop high-resolution computer modelling to represent coastal water dynamics is helping Indonesia build the expertise and infrastructure to tackle devastating flooding.

Kampung Apung, an informal settlement in the Kapuk district of Jakarta, Indonesia, floods during the rainy season and is connected to neighbouring areas by a metre-wide causeway. © Afriadi Hikmal/Getty Images

Indonesia's capital has been victim to coastal flooding for centuries. Climate change is now increasing the intensity and regularity of these floods. The most recent major incursion, in 2013, claimed dozens of lives and forced tens of thousands to abandon their homes.

The causes of Jakarta's flooding are many and varied. Already a low-lying city (averaging just eight metres above sea level) parts of Jakarta are also subsiding. The city is therefore particularly vulnerable to rising sea levels, especially during spring when tides are higher. Increased rainfall and changing land use, meanwhile, are

swelling local rivers. Jakarta's river flood risk is predicted to rise 180 per cent between 2015 and 2030. The Jakarta Research Council therefore asked CTCN for technical help to develop solutions and build in-country capacity to tackle its flooding problem.

Project objective

There were two stages to the project, the first being to assess Jakarta's flood risks and hazards, followed by the design of climate-resilient measures to reduce the scale of flooding and its impact. To achieve these objectives, the following activities were identified:

- develop a high-resolution hydrodynamic flood model to evaluate 'hard' and 'soft' engineering solutions to reduce flooding risks in a pilot area of Jakarta (hard = solid, man-made structures like sea walls, groynes and rock armour; soft = enhancing natural solutions to protect coasts, such as widening beaches or planting trees in coastal dunes);
- survey Jakarta's inhabitants to find out their perceptions of flooding, what they considered acceptable risk, and their preferred adaptation options;
- organise a series of technology transfer workshops to strengthen local expertise in hydrological modelling and urban infrastructure options;
- formulate policy recommendations to develop climate-resilient urban infrastructure to reduce flooding risks;
- develop funding opportunities to expand the utilisation of the hydrodynamic model;
- share knowledge gained through the project with other cities in the Global South that face similar flooding issues.

Participants

The Jakarta Research Council, on behalf of the Provincial Government of Jakarta, applied to the CTCN for technical assistance. UNEP-DHI Partnership led the implementation, with the help of several expert partners in Indonesia. These included: the Jakarta Research Council, Indonesia's Agency for the Assessment and Application of Technology, Gadjah Mada University, the Indonesian Institute of Sciences, the University of Indonesia, the Bandung Institute of Technology and Bogor Agricultural University.

Jakarta's country representative and CTCN focal point for the project was Ms Nur Masripatin of Indonesia's Ministry of Environment and Forestry.

Challenges

The biggest challenge was gathering the large amount of necessary data to create the hydrodynamic model in the limited time available. The data were held by several different institutions, which made information gathering a time-consuming process. Cooperation was achieved through much lobbying and numerous meetings with government bodies.

There was also more work required to make the data from different sources consistent, which further added to delays in processing the data and calibrating the model. However, the model was built and successfully represents the floods that took place in 2007 and 2013.

The original plan was to conduct household surveys for the socio-economic impact assessment once the hydrodynamic modelling had been completed. To win back time lost in the data gathering stage, it was decided that the surveys should be conducted in tandem with developing the model. The timing of surveys and focus group discussions also coincided with the Jakarta governor election. Some respondents refused to participate in interviews, as they assumed these were connected with the election. Some households also took longer than expected to complete and return their survey answers.

Climate action

The project supports Sustainable Development Goal (SDG) 13 (tackle climate change) and Indonesia's Nationally Determined Contribution. It helped Indonesia to improve knowledge management and policy on climate change adaptation and disaster risk reduction. It also helped the country to develop key measures on coastal and flood protection. Specifically, the government of Jakarta has used the hydrodynamic modelling to identify areas of the city that are most vulnerable to flooding. The software has also allowed them to identify the most relevant technology solutions to tackle the problem.

Government agencies now have enhanced expertise to formulate policy and action plans – both to reduce flooding and advance climate-resilient city planning in Jakarta.

Other benefits

Jakarta has shared the decision-making tools and lessons learned from the project with other major Asian coastal cities. This South–South cooperation has spread expertise throughout the region and boosted the impact of the CTCN's technical assistance.

Thanks to the capacity building on financing, Jakarta received funding interest from the government of South Korea and the World Bank to expand the original pilot to all affected areas of Jakarta.

All of these benefits are likely to contribute to a significant reduction in loss of life and property.

In addition to furthering the climate action goal, SDG 13, the project supports SDG 9 (build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation) and SDG 11 (make cities and human settlements inclusive, safe, resilient and sustainable). ■

KEY FACTS

Organisations involved:
CTCN, UNEP-DHI Partnership, Jakarta Research Council, Ministry of Environment and Forestry (Government of Indonesia), plus several local experts

Budget:	$240,000
Start date:	July 2016
Completion date:	January 2018

Benefits:
Enabled government of Jakarta to identify areas of the city that are most vulnerable to flooding, strengthen local expertise in hydrological modelling and urban infrastructure options, and formulate a plan to best address flooding in the pilot area.

Case study:
Strengthening infrastructure

A CTCN project to make Antigua and Barbuda's critical buildings climate-resilient will bring long-lasting benefits to these islands.

By **Egbert Louis**, Principal Consultant, ECMC Ltd, Saint Lucia

Given the vulnerability of Small Island Developing States (SIDS) to natural disasters, the recognisable impacts of climate change, and the devastating effect of Hurricane Irma in 2017, it was essential that the Government of Antigua and Barbuda (GOAB) managed the reconstruction of its public infrastructure by 'building back better'. This commitment was driven by four major objectives:

1. Devising a strategy whereby critical public buildings and emergency services can withstand the impact of major local disasters, particularly hurricanes and floods.
2. Retrofitting existing public building stock to minimise the impacts of potential future climate-induced disasters.
3. Leading a sustainable reconstruction process that reflects projected climate change impacts, by conducting critical assessments, developing adaptation measures and building capacity within its technical human resource base.
4. Preparing appropriate bid packages for each of the selected facilities. These can then be used by the GOAB as guidance for further funding proposals and investment plans, and for future design and structural specifications of public buildings.

Basis for selection

Given their vulnerability, SIDS need to ensure that critical public buildings can continue to operate before, during and after emergency events. This requirement is particularly relevant given the satellite nature of the infrastructure considered, vital to the health and welfare of the population. Therefore, some of the public facilities that were identified for the project included:

- hospitals;
- police stations;
- health/medical centres;
- fire stations;
- defence force facilities;
- other critical public facilities such as the Ministry of Finance, Ministry of the Environment and the national emergency headquarters.

The buildings' ability to operate was taken from the standpoint of both the physical infrastructure and their services input.

Parties and capabilities

To realise its objectives, the GOAB sought and received technical assistance from the Climate Technology Centre and Network (CTCN). The CTCN then engaged one of its network members (ECMC Ltd of Saint Lucia) to work with the Ministry of the Environment and other partners from Antigua and Barbuda.

The first task was to identify the most critical public buildings to include under the project. ECMC's team comprised its own engineers from Saint Lucia and a local Antiguan engineer, Trevor Gonsalves.

The Ministry of the Environment and its local team of building inspectors had identified the buildings to be assessed. The ECMC team provided training to make rapid, yet comprehensive, assessments of the buildings and infrastructure, identify deficiencies and select appropriate mitigation measures.

The involvement of the local ECMC engineer was a valuable asset to the assessment process by assisting the local teams as well as conducting critical assessments whenever required. A UN environment expert provided overarching guidance about relevant information for preparing a concept note for funding.

> **SIDS need to ensure that critical public buildings can continue to operate before, during and after emergency events**

Timeline and deliverables

The contract for ECMC's services started on 20 June 2018. The Department of Environment's local team, coordinated by ECMC and its local counterpart engineer, worked for a period of 34 weeks to achieve the following deliverables:

1. A draft bid package covering the generic work scope, method statements, quality standards and defects rating.
2. A set of guidance notes for the data collection, detailed work and damage assessment, and cost estimates for mitigating measures.
3. On-site training, guidance and material on structural inspections and works estimates.

UN Secretary-General António Guterres and Gaston Browne, Prime Minister of Antigua and Barbuda, survey Codrington town, Barbuda after the region was hit by back-to-back, category 5 hurricanes. © Rick Bajornas/UN Photo

4. Developing 34 detailed work packages consisting of a works list, adaptation and retrofitting measures, a basic aerial site plan and engineering cost estimates for each work package.
5. Developing standard structural and retrofit drawings covering the defects and deficiencies observed during the detailed assessment of the critical public buildings.
6. Producing technical advisory notes for the 2018 procurement and implementation activities. The notes also included recommendations on appropriate procurement methods to be adopted for the work packages developed.

Challenges and solutions

There was one major challenge that was quickly resolved.

The pace at which the building inspection forms were being submitted and their completeness was the main contributory factor for the extended duration of the project.

The ECMC team was able to address the situation by conducting separate visits to the buildings and performing comprehensive reviews of the photographs provided.

Site plans which were planned to be part of the work packages had to be replaced with aerial photographs of the respective building sites.

Climate action objectives

Some of the climate action objectives achieved were based on addressing issues related to increases in storm intensity, heavier rainfall periods and a reduction in average rainfall.

Although the issue of storm surge was viewed as a climate action objective, which should be addressed, none of the critical buildings selected was located on the coastline.

Some of the critical mitigation measures included the use of potable water and rainwater harvesting storage, retrofit of roofs to include the use of trusses and reduced spacing of fasteners, the use of impact windows and hurricane shutters and the use of standby generators for each of the 34 work packages.

Other development benefits

Based on feedback from the local participants in the project, two critically distinct benefits were derived.

The first was capacity-building for carrying out rapid and detailed assessments of critical assets to expedite comprehensive work packages for repair and retrofitting of public buildings after storm damage.

The second was the automatic development of a database of standard costs for critical mitigation measures, which can be used on similar future projects or for any disaster-related damage assessment exercise. ■

Selling fish at Gizo market, Solomon Islands. Warming oceans and acidification are threatening the coral reefs and the fish that depend on them. © Linda Roche/DFAT

Big threats to small islands

The next 10 years – designated the UN's Ocean Decade – may decide the very survival of Small Island Developing States. It calls for technology-led, co-ordinated action, starting now.

By **Peter Thomson**, UN Secretary-General's Special Envoy for the Ocean

Hope springs eternal. When in dark moments I consider the incontrovertible facts of climate change and such deeply disturbing symptoms as ocean acidification, the death of coral, the extinction of species, and steadily rising sea levels, I do not allow myself the indulgence of despair. It's not that I choose optimism over pessimism, for neither is as useful as hard-nosed pragmatism. It is because I have faith in two of the greatest qualities of our species.

Ever since our ancestors walked forth from East Africa, through all the wrong turns and man-made disasters met along our journey, two innate strengths carried us forward. By deploying them we developed agriculture, we created urbanised industrial societies, and we invented technologies that have taken us to the Moon and back.

Climate and ocean change are inextricably linked. As humanity's practices are the causes of the problems, so they must be part of the solutions

The first quality is that of sharing, without which homo sapiens would not have been able to go beyond hunting and gathering. The second is that of innovation, the quality that took us from the Stone Age to the Space Age. When faced with a Malthusian crisis – be it famine, plague or war – we have either applied these two qualities to the best of our abilities, or we have succumbed. The alternatives of selfish greed and regression have worked for some in the short term. But in the long haul they succumb, while human progress resumes its march in search of the common good.

Here in the 21st century, facing up to the grim realities of climate change and the fact that we have brought this crisis upon ourselves, we must now devise better ways of sharing. We must also apply ourselves to innovation as never before. These fundamental principles underlaid the 2015 adoption by UN Member States of the 17 Sustainable Development Goals (SDGs), when nations put innovation and technology transfer into the heart of the goals.

SIDS on the front line

It is a well-accepted fact that Small Island Developing States (SIDS) are at the frontline of the destruction that climate change will bring upon many long-existing economic, social and environmental conditions. Without effective adaptation and mitigation measures, some islands will lose their ability to maintain human habitation, forcing migration and unthinkable cultural and environmental loss.

If SIDS are at the front line of rising sea levels, it is sobering to think of the hundreds of millions of people living in the food-basket river deltas and low-lying coastal lands of the continents who will also be faced with inundation. These are indeed times for intensified innovation and technology transfer.

It is also now broadly recognised that climate and ocean change are inextricably linked. As humanity's practices on both land and sea are the causes of the problems, so they must both be part of the solutions. That linkage is amply demonstrated by the fact that all three exacerbating, life-threatening ocean changes now underway (deoxygenation, acidification and warming) are a consequence of the same anthropogenically created greenhouse gases (GHGs) that are causing climate change.

It was because of their place on the front line that SIDS recognised the changes underway. They rang the alarm bells at the United Nations in the years when the SDGs were being negotiated. One of the main results of that push was the creation of SDG 14: conserve and sustainably use the oceans, seas and marine resources for sustainable development.

It should thus come as no surprise that one of the 10 targets of SDG 14 is to increase scientific knowledge, develop research capacity and transfer marine technology. In other words, step up our innovation and better share our efforts and results. That target is specifically aimed at improving the health of the Global Ocean and enhancing the contribution of marine biodiversity to the development of developing countries – in particular the SIDS and least developed countries.

It is in the spirit of innovation and sharing that SIDS have welcomed the

United Nations declaration of 2021 to 2030 as the UN Decade for Ocean Science for Sustainable Development. Through comprehensive observation, the Decade is expected to: complete our mapping of the ocean floor; develop our understanding of the multi-stressors affecting the Global Ocean and its incredibly complex and diverse ecosystems; and scale up our capacity development to provide better climate services and disaster warnings. It is envisaged that by the end of the Decade we will have an interoperable portal of ocean data available to all. Through this we can make decisions to protect both the Ocean's biodiversity and human security.

SIDS have much to give to and gain from the Ocean Decade. They are scattered about the Ocean like ready-made observing stations. Their human inhabitants are well attuned to the Ocean's many characteristics.

Installing an Automatic Weather Station (AWS) in the Cook Islands. © Melina Tuiravakai/Government of Cook Islands

Forging partnerships

In a spirit of North–South and South–South partnership with governments, NGOs, academics, business and philanthropies, the SIDS must fully engage with the Ocean Decade. Through it, their marine institutes will be upgraded, while their young people will be trained to become world-class marine scientists and technicians. The island countries will acquire the scientific knowledge and marine technologies needed to maintain a sustainable relationship with the Ocean in the course of changing conditions. For SIDS to have the capacity to effectively combat the challenges of climate change, the centrality of technology transfer is key.

We need to help SIDS build the capacity to assemble data on the causal links to resource impact, and the multiple threats posed by climate and ocean change. This is so that mapping and analysis can be carried out to enable user-friendly visualisations to be developed for advocacy and awareness. Forecasting change to better manage risks will depend on effective technology transfer and development. This will be critical for SIDS' shipping, ports, marine tourism, pollution prevention, and the reduction of GHG emissions in sea transportation.

Likewise, work is at hand on the use of remote sensing, autonomous vehicles and satellites for monitoring and mitigating coastal habitat degradation, changes in sea surface temperature and real-time fish-stock assessments.

We are also making strides in developing integrated early-warning systems based on multi-disciplinary expertise and access to better data, which is in turn informing policy and management regimes. Central to all of this is access to fast and cheap internet with high bandwidth, without which the uptake and power of technology across SIDS will be delayed and dissipated.

To achieve SDG 14, partnerships will be central to all good efforts. Joining with UN Member States and the United Nations System, we must now see non-governmental organisations, the private sector, the scientific community and philanthropic organisations forging partnerships to mobilise necessary actions. No one party can succeed on its own, for SDG 14 is a universal responsibility. The Ocean is the common heritage of mankind.

> **SIDS have welcomed the UN declaration of 2021 to 2030 as the UN Decade for Ocean Science for Sustainable Development**

The UN Ocean Conference of June 2017 was a global game-changer in its raising of awareness of the deep problems the Ocean now faces. Amongst its many positive outcomes, the conference witnessed the formation of an impressive array of multi-stakeholder partnerships and more than 1,500 voluntary commitments to implement SDG 14. My appointment as the UN Secretary-General's Special Envoy for the Ocean arose from the conference, with terms of reference to support the achievement of SDG 14.

It has been encouraging to see the spread of ocean action initiatives around the world in the years since the 2017 conference. A particularly noteworthy example was the Global Sustainable Blue Economy Conference, convened by the government of Kenya and co-hosted by the governments of Canada and Japan in Nairobi in November 2018. The conference saw marine science, research and technology transfer all receive wide support.

Now preparations are underway for the 2020 UN Ocean Conference in Lisbon on 2–6 June next year. The overarching theme will be scaling up ocean action based on science and innovation for the implementation of SDG 14. ■

Evaluating crop results at the Climate-Smart Village (CSV) of Olopa, Guatemala. © Alexandra Popescu/CCAFS/CGIAR

Effective partnerships

Climate action demands cross-border collaboration. What are the essential ingredients for creating successful multinational climate projects?

By **Karsten Krause**, Head, Climate and Energy Department, German Environment Agency

Cooperation among multi-cultural teams and collaboration on new solutions is essential in meeting climate objectives, as well as in creating new jobs and growth. Urban infrastructure, land use productivity and clean energy systems offer a potential to greater efficiency, structural transformation and technological change towards climate-friendly, sustainable development.

Transformation requires bringing new partners together and managing the uncertainty that comes with innovation. Pivotal to moving from pilot projects towards mainstream collaboration is to build trust among the shareholders and stakeholders of a project.

We need effective enabling environments to upscale from the current level of climate action towards the ambition laid out in the Paris Agreement. Private investment, alongside and attracted by public investment, is crucial to scaling up climate finance and closing current investment gaps. And, most importantly, we need to establish better ways of building lasting partnerships to facilitate North–South, South–South and triangular cooperation.

Enabling change is a location-specific process. An established solution in one country may be unknown, not available or not accepted in another. The interaction of entrepreneurs, universities, schools, governments and technology users creates an ecosystem, unique to a location and a technology. While an entrepreneur pushes a solution in one village, farmers can oppose it in the next. If the last few decades of renewable energy projects have shown us anything, it is that public support for them depends on taking a participatory approach that promotes local ownership.

At the national level, a stable regulatory framework is a precondition for transferring intellectual property and investing in a country. Given the high initial investment costs, the development of many climate technologies can be vulnerable if regulations around them are liable to change.

For many countries, the 'import' and adaptation of a solution can lead to an accelerated market introduction and take-up of climate technologies. Focus should be on learning and on first-to-market approaches, where investment models, risk management and application models reflect national circumstances and capabilities.

National characteristics have a significant influence on shaping innovation outcomes. National innovation activities depend on size and income level. Smaller countries or countries with limited national

research investments may be more focused on incremental or adaptive innovation. Richer countries, meanwhile, can support early stages of technological development, achieving a critical mass to push the technological frontier.

The non-linear interaction of cultural, organisational, behavioural and technological factors can be considered as a national system of innovation or as the enabling environment of activities along the technology cycle.

UNFCCC governance

The United Nations Framework Convention on Climate Change (UNFCCC) plays a pivotal role in connecting potential partners. Already since 2001, more than 80 developing countries have conducted Technology Needs Assessments (TNAs) to determine the mitigation and adaptation technology priorities of a country.

TNAs and resulting action plans also form important inputs for other national processes related to the UNFCCC: Nationally Appropriate Mitigation Actions (NAMAs), National Adaptation Plans (NAPs) and National Communications (NCs), and to develop Nationally Determined Contributions (NDCs). These processes provide a portfolio of future projects, tracking needs for new equipment, techniques, services, capacities and skills necessary to mitigate greenhouse gas emissions and reduce vulnerability to climate change.

A second component to coordinate national actors to enhance the enabling environment is the national designated entities (NDEs) for climate technology development and transfer. NDEs, nominated by over 160 UNFCCC Parties, are linked to the Climate Technology Centre and Network (CTCN). NDEs play a fundamental role as an access point and coordination hub for technology. The nominated individuals ensure that requests for technical assistance submitted to the CTCN reflect their national circumstances and priorities.

NDEs also ensure that support that the CTCN provides is well coordinated at the national level with other processes that address climate change. A key task is to ensure the engagement of relevant ministries, focal points for other UNFCCC mechanisms, the private sector, civil society and academia (as appropriate) in a request. This function is organised differently by different Parties. While many Parties locate the NDE in an environmental or climate ministry, other countries place theirs in economic affairs departments or a specialised agency.

Through the NDEs, the CTCN helps developing countries to prioritise their technology needs, research potential regulatory and policy barriers, and support technology deployment. Crucially, it helps to identify sources of additional public or private funding.

The CTCN provides these services by mobilising expertise on policy and technology support from a global network of finance, NGO, private sector and research stakeholders. Local and national stakeholders in developing countries convey their clean technology-related needs to the CTCN via a national focal point. Upon receipt of a request, the CTCN conducts an open bidding process among its network members and contracts them directly for their services.

Network members represent a broad array of expertise in technology development, deployment, capacity-building, finance, investment and policy. As the CTCN helps countries to create environments that are conducive to attracting and supporting technology implementation, many of its technology projects focus on both soft and hard technologies. These projects take the form of training, assessments, feasibility studies and guidance on policy and regulatory structures.

CTCN technical assistance needs to be seen as seed-funding to enable larger-scale projects at a later stage. This could be done either by identifying technology partners or financial institutions to upscale and implement the results of technical assistance requests.

Successful partnering

Beyond individual projects, the mainstreaming of climate action requires longer-term partnerships. Trust develops over generations of short-lived projects. Successful partnering across different countries and regions depends on the political buy-in of leaders, broad stakeholder engagement and scientific support. Those

> **The CTCN and the NDEs can link good business models and new technologies with local needs**

three factors can be influenced to raise ambition.

A joint vision demonstrates long-term commitment and the direction in which climate policies are headed. It also gives various communities such as the private sector clear signals to adapt to the changing policy environment. Communicating this vision, associated policy goals and progress to a wider public helps to foster understanding and creates transparency.

It is also important to link this vision to the benefits and risks of climate measures. To convince leaders and citizens of the need to take action, we must frame the climate-related problems in a way that resonates with their way of thinking. It is also important to get the timing right and identify key people to approach.

A prerequisite for successful stakeholder engagement is being aware of the goals behind the actions. It is important to reflect on past experiences in engaging with stakeholders, and evaluate success stories as well as failures. This process should also comprise developing a preliminary strategy based on local needs. Local benefits, such as employment opportunities or financial revenues, help to enhance acceptance rates.

Private-sector involvement is a key driver of technological innovation and transfer. Even inside the EU, most innovation spending is realised by the private sector and technologies are owned and operated by private actors. We need a differentiated approach to work with technology producers, banks, engineering companies and small and medium-sized enterprises.

Despite the business potential, a knowledge gap needs to be bridged to

balance perceived risks and to leverage much higher investments than can be obtained through the public sector. Facilitation through trusted national actors, such as the NDEs, may help companies to enter new markets. But they are more important to help local stakeholders to assess the direct and indirect effects of initiating an innovation or first-of-a-kind project. Learning from best practice elsewhere and direct communication with a not-for-profit adviser builds trust.

To maximise opportunities, both in the EU and in developing countries, cooperation and networking are key. Joint projects with international partner countries and exchanges of knowledge help to create synergies and allow the sharing of experiences on how best to innovate.

To accelerate matchmaking opportunities between technology providers and interested parties in developing countries, the CTCN was launched in 2014 with support from the EU. Five years later, more than 170 clean technology transfers are completed or underway in more than 90 countries, in sectors ranging from agriculture and energy to industry and waste management. The CTCN NDEs are an access point into the national innovation system.

Conclusion

If we are to scale up from individual projects towards effective climate action partnerships, establishing trust is essential. The Paris Agreement reconfirmed the role of technology development and transfer as one of the pillars of the UNFCCC negotiations. But we need to encourage new participatory ways to facilitate North–South, South–South and triangular cooperation.

The CTCN and the NDEs can link good business models and new technologies with local needs, to create a sound environment and sustainable economic activities. As increasingly important networker and information brokers, the CTCN and the NDEs can help to build trust and bring those actors together who can and want to make a difference. ■

The views expressed are those of the author and do not reflect the official policy or position of either the European Commission or the German Environment Agency.

EUROPEAN COMMUNITY SUPPORT FOR THE CTCN

The European Commission, on behalf of the European Union, has provided continuous funding assistance to the CTCN since its launch in 2013, supporting networking, knowledge sharing, capacity building and technical assistance for climate change action. To date, the EC is the single largest donor to the CTCN.

Networking: The Climate Technology Network is vital to the success of the CTCN's technology transfer services. The civil society, finance, private sector and research institutions that comprise the Network, together with National Designated Entities (NDEs – technology focal points selected by each country) from 160 countries, share technology expertise through the Centre's knowledge sharing, capacity building and technical assistance activities that enable the CTCN to deliver on its mandate.

Knowledge sharing: The EC's support has enabled the CTCN to improve the availability and accessibility of knowledge on climate technologies. Through its knowledge portal, www.ctc-n.org, the CTCN offers information on a broad spectrum of adaptation and mitigation technology sectors, as well as country profiles. The knowledge portal is now among the world's largest online sources of climate technology information.

Capacity building: Enhancing human and institutional capacity in developing countries in order to remove barriers to decision-making, implementation and financing of climate is a key aspect of the CTCN's work. With support from the European Commission, CTCN Regional Forums have provided a platform for in-person training and best-practice sharing for NDEs. They have also facilitated dialogue between NDEs, Network members and financial institutions. Twenty-two regional technology forums have engaged 900 climate technology stakeholders over the past five years.

One example of this was a pilot training of trainers programme on "Design Thinking for Climate Change Innovation". Design thinking is an approach to innovation that integrates the needs of people, the possibilities of technology, and the requirements for business success.

Hosted at the Tanzania Commission for Science and Technology, the training brought university educators and National Designated Entities from five African countries together to participate in a structured innovation design curriculum, in order to foster the creation of relevant endogenous solutions to local and national challenges. To deliver the training, the CTCN partnered with INDEX, a Danish organisation that works to build innovation capacities for sustainable solutions development.

Technical assistance: The CTCN provides technical assistance in response to requests submitted by developing countries via their NDEs. Upon receipt of such requests, the Centre quickly mobilises its global Network of climate technology experts to design and deliver a customised solution tailored to local needs.

Laos is one of the countries to receive such assistance. It is considered highly vulnerable to climate change, particularly from climate-induced extreme events (floods, droughts and soil erosion) that could significantly impact the country's hydrology, ecology, agriculture, fisheries and hydropower development. Six Laotian provinces therefore asked the CTCN to assist in identifying the key climate risks to their areas and propose relevant actions to address them.

Danish Network member DHI Centre on Water and Environment conducted city climate vulnerability assessments and identified the most impactful ecosystem-based adaptation interventions to mitigate the risks. Laos was also provided with assistance on the development of a successful $10 million Green Climate Fund proposal in order to fully implement the guidance and scale it up to include additional at-risk provinces in Laos.

Cooking street food on a wood fire in Chiana, Ghana. An ECOWAS initiative to give Ghanaian women access to LPG stoves is designed to aid economic empowerment, health, quality of life and preservation of forests. © Axel Fassio/CIFOR

Empowering women as climate actors

Two projects, in Senegal and Ghana, show the transformative power of simple technology to empower working women.

By **Monica Maduekwe**, Coordinator, ECOWAS Programme on Gender Mainstreaming in Energy Access (ECOW-GEN)

In West Africa, an energy revolution is quietly gathering pace. Energy poverty is high across the region, with less than half the population having access to electricity. This lack of access disproportionately affects women more than men.

Recognising that gender equality will play a key role in driving a sustainable energy future, the 15 countries of the Economic Community of West African States (ECOWAS) have adopted the first-ever regional policy on gender-responsive energy development. The Climate Technology Centre and Network (CTCN) supported implementation of the policy, which seeks to ensure improved access to affordable, reliable and sustainable energy for all, through projects and programmes that meet the energy needs of both women and men.

In 2014, the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) launched the ECOWAS Women's Business Fund. This initiative was designed to enable women to start up and scale up innovative energy businesses across West Africa.

The fund was established on the premise that women, if given the right support, can be innovative and creative,

> **The initiative was designed to enable women to start up and scale up innovative energy businesses across West Africa**

and can make excellent business managers. Women, if adequately equipped, can also actively engage and participate fully in driving this new era of green energy development in West Africa.

To demonstrate that this vision was possible, ECREEE awarded small grants of up to €20,000 to two pilot projects:

- Promotion of Anomena improved LPG stoves as a clean-energy initiative for cooking – by Anomena Ventures in Ghana;
- Economic empowerment of the female fish producers of Bargny – by Action Solidaire International in Senegal.

In 2018, the two projects were assessed to determine if they met their objectives. The results have been remarkable.

1. Promotion of Anomena improved LPG stoves as a clean-energy initiative for cooking

Results and achievements

Street food vendors and women entrepreneurs operating from homes in Ghana were supplied with Anomena liquefied petroleum gas (LPG) stoves to empower them economically. At least 5,000 women were reached through awareness-raising and gender-sensitising workshops as well as training on the safe use of LPG appliances.

As a result, workers and school children now have access to fast cooked meals in the morning. Women entrepreneurs have access to improved stoves, and confidence in how to use them. Beneficiaries are able to cook within their own homes.

Lessons learnt

Women are now in a position to purchase their own stove, as they are able to pay for it in instalments. The time women save by using these stoves means they now have more time to spend with their families and to take part in other activities.

The stoves completely eliminate the need to burn wood fuel. This saves school children from the dangers of smoke inhalation and helps to preserve forests.

2. Economic empowerment of Bargny business women

Results and achievements

The project has transformed the earning potential of the women that process fish in Bargny, Senegal. The project provided them with their own 4,000 square metre plot of land, which the women themselves own. The project built 13 improved furnaces on this plot. Having access to these improved furnaces means the women can now smoke up to 15,600 kg of fish per day, worth €13,846. Prior to the project, the women, using the traditional, yet much wasteful technique, were able to produce 7,000 kg of marketable fish per day.

A female-majority steering committee was set up to manage the micro-lending fund created through the project. These women were equipped with the capacity to operate and manage the fund themselves. The project provided the initial funding, which supported the women in negotiating an arrangement with a financial institution for a line of credit worth €15,267.

The credit facility allows the women to buy the raw materials they need to work at a time that suits them. Once dependent on middlemen, these women are now more self-reliant and can negotiate the market price of what they produce in line with their commercial interests.

Lessons learnt

The most important challenge in setting up an energy-related project for women is to make sure they take ownership of it.

The project shows that women have the capacity to generate high amounts of revenue through work if they are equipped with modern, energy-efficient technologies.

It also demonstrates the importance and value of establishing a micro-lending fund as part of a project – whatever the nature of the project designed to support women. Such a fund should work towards increasing women's access to finance and give them autonomy when it comes to accessing raw materials.

About the ECOWAS Women's Business Fund

The ECOWAS Women's Business Fund was established through the financial support of the Austrian Development Agency (ADA) and the Spanish Agency for International Cooperation and Development (AECID). The initiative has since been scaled up through a CTCN-supported project, Mainstreaming Gender for a Climate Resilient Energy System in ECOWAS. ■

CTCN SUPPORT FOR ECOWAS GENDER MAINSTREAMING CAPACITY

Forty-two people (20 men, 22 women) within 15 newly established energy ministry gender focal units, as well as relevant civil society representatives, participated in a capacity assessment and extensive training on gender analysis of energy policy reports and project documents, gender mainstreaming and gender budgeting in the energy sector.

The project was implemented by CTCN Network members Partners for Innovation and MDF West Africa Ltd.

In addition, the CTCN supported women energy entrepreneurs together with PFAN through mentoring on project development and financing, and arranging investor meetings for participants.

"It was exciting to meet a lot of women across the continent that are doing so much in the renewable energy space from off-grid energy to waste-to-energy," said Hannah Kabir, CEO, CREEDS Energy, Nigeria. "It was definitely an eye opener but also encouraging to see that there are a lot more of us out there doing good things."

Harnessing CTCN services

How can countries make the most of what the Climate Technology Centre and Network (CTCN) has to offer?

By **Elisha N. Moyo**, Principal Climate Change Researcher, Ministry of Environment, Water and Climate, and CTCN National Designated Entity (NDE) for Zimbabwe

Despite developing countries' commitments to climate change adaptation and mitigation efforts, the road to meeting international obligations and national aspirations remains long. Climate change is a fast-evolving science and is both cross-sectoral and multi-dimensional. This can make understanding climate change challenges and opportunities difficult.

The sheer technical complexity of the climate change challenge explains, in part, why developing countries continue to lose lives, property, livelihoods and infrastructure to climate change. It is also why developing countries generally fail to access many of the resources – such as the Green Climate Fund (GCF) – that are designed to accelerate climate action.

A key resource that countries can call upon to help tackle climate change – and remove barriers to climate action – is the Climate Technology Centre and Network's (CTCN's) technical assistance. CTCN has responded to four such technical assistance requests over the past four years in Zimbabwe

To make the most of what CTCN has to offer, beneficiary countries could consider the following points.

Understanding climate technology scope

First, beneficiary countries need to understand the climate technology conceptual framework in its broader sense: that it encompasses knowledge, skills, techniques and equipment to reduce greenhouse gases or adapt to climate change.

This will enable developing countries to seek appropriate transformational technical assistance that deals with the root causes of their vulnerability to climate change, as well as other systemic issues that are often ignored. Often, beneficiary countries seek hardware investments such as equipment at the expense of the critical enablers of sustainable home-grown climate action or co-generated climate solutions.

Understanding the CTCN

It's also critical that countries understand the CTCN's mandate, services and opportunities. The CTCN's objective is to enhance the development and transfer of technology for action on climate change. Its clear mission is to stimulate technology cooperation and enhance the development and transfer of technologies to developing countries.

As well as technical assistance, the CTCN offers developing countries services such as knowledge-sharing and training, as well as collaboration on climate technologies (including linking climate technology projects with financing opportunities).

Aligning the CTCN offer with countries' needs

Beneficiary countries should align their requests to the CTCN with key global climate change governance frameworks. These include the UN Framework Convention on Climate Change, the Paris Agreement and the Sustainable Development Goals, as well as key climate change findings and recommendations from the Intergovernmental Panel on Climate Change and other bodies.

Countries should align their technical assistance requests with national climate plans such as Nationally Determined Contributions (NDCs), Technology Needs Assessments (TNAs) and Technology ActionPlans (TAPs). To strengthen the relevance of CTCN services in countries and facilitate the uptake of findings from CTCN projects, it is critical that countries are sensitive to their own national circumstances.

Countries should clearly seek to further low-carbon, climate-resilient efforts that are in line with their developmental aspirations, economic blueprints and needs.

Identifying niches

The best way to effectively utilise CTCN services is to identify niches where those services can have most impact. For example, countries could seek to de-risk possible future climate investments before scaling up potential climate actions through feasibility studies using CTCN's various network members' expertise.

The best way to effectively utilise CTCN services is to identify niches where those services can have most impact

The CTCN has more than 500 network members in the private sector, public sector, academia and civil society organisations.

Using national climate technology focal points

Climate technology focal points – the National Designated Entitles or NDEs to give us our official title – play a critical role in enabling successful CTCN projects. Our role is to increase knowledge of CTCN services and opportunities within beneficiary countries, and to facilitate technology transfer 'matchmaking'.

Beneficiary countries could call on NDEs to help them – through CTCN services – to achieve the nationally determined contribution (NDC) targets. For example, the CTCN could help if a country needs practical technical help to develop a policy framework, user manuals, training or minimum energy performance standards (MEPS).

Opening up CTCN opportunities to innovators, new actors and the private sector

CTCN supports endogenous technology development and transfer. There is therefore a powerful opportunity for innovators and new climate actors to utilise CTCN resources to test their innovations before deployment (see article on page 47). Involving a wide range of stakeholders and facilitating ownership of CTCN processes and outputs is a critical foundation for widespread deployment of climate technologies, products and services.

CTCN can help countries to generate new private investment in climate action. For example, CTCN can facilitate exchange visits and organise knowledge-sharing platforms. In these, climate technology champions with similar national circumstances share experiences on how CTCN services have transformed economic, social and environmental development in their countries.

Showing the economic value in energy and water efficiency, for example, through initiatives like these could encourage the private sector to invest in low-carbon technologies and production lines.

Success in Zimbabwe

Zimbabwe has made use of the CTCN to develop high-quality project proposals to request part of its 2019 GCF readiness funds. With CTCN support, Zimbabwe is more likely to succeed in its bids for funding to respond to the country's climate mitigation and adaptation needs. This demonstrates how beneficiary countries could make use of CTCN services to further their climate change management programmes.

A number of other CTCN projects have been completed in Zimbabwe, including the development of a climate-smart agriculture manual, which was integrated into all national agriculture learning curricula and forms a standard approach against climate change and promoting sustainable development.

Zimbabwe continues to make use of CTCN services to identify and remove barriers to effective implementation of the Paris Agreement through requesting technical assistance or capacity-building to close knowledge gaps. ■

A new arrival at the solar-powered Nkayi District Hospital, Zimbabwe. The hospital is capable of running life-saving services and performing operations when there is no grid access, solely using stored solar power.
© Karin Schermbrucker/UNDP

A member of the cooperative 'Orissa Tribal Women Barefoot Solar Engineers Association' installing solar panels in Tinginaput village, India. Promoting gender neutrality in its climate solutions is central to CTCN's philosophy. © Abbie Trayler-Smith/Panos Pictures/ Department for International Development

Technology to drive change

The Climate Technology Centre and Network (CTCN) has a pivotal role to play in helping countries develop technological solutions essential for tackling climate change.

By **Mette Møglestue**, Director, Department for Climate, Energy and Environment, Norad (Norwegian Agency for Development Cooperation) and former Chair, CTCN Advisory Board

Climate change is undermining our efforts to achieve the Sustainable Development Goals (SDGs). Without urgent action, climate change impacts could push an additional 100 million people into poverty by 2030. Aligning development and climate change is a challenge for all countries, in particular for the most vulnerable nations like small island states and sub-Saharan African countries.

So I am pleased to observe the Climate Technology Centre and Network's (CTCN's) hard work and influence, assisting developing countries in their search for climate technology that is relevant for their investment plans across different sectors.

Norway has put climate change mitigation and adaptation at the heart of its foreign and development policy. The Norwegian government will increase the level of climate financing to reach the goals of the Paris Agreement. It will prioritise measures that are in line with other countries' plans for climate action and low-emission development.

The next generation of countries' Nationally Determined Contributions (NDCs) will be delivered to the United Nations Framework Convention on Climate Change (UNFCCC) next year. In line with the Paris Agreement, the level of ambition of the NDCs will increase.

Access to technology

Technology may help with the solutions needed to achieve these increased ambitions. The CTCN, as the operating arm of the Technology Framework of the Paris Agreement, is playing a crucial role in ensuring that developing countries have access to the necessary technology.

Firstly, the CTCN can monitor and measure the current status of emissions and resilience. This is essential for

> **Climate technology actions must ensure that both women and men are engaged in decision-making processes, and in the development and use of technologies**

countries to develop their own climate change emissions reporting, according to the transparency framework agreed at COP24 in Katowice.

Secondly, the CTCN secures energy access from renewable resources such as wind energy, solar power and hydropower. And equally important, the CTCN assists in reducing GHG emissions by improving energy efficiency and waste management, and designing better industrial and agricultural processes.

And thirdly, technology is assisting countries in adapting to the adverse effects of climate change through the CTCN providing technical assistance. The aim is to enhance the use of climate technologies such as drought-resistant crops, sea walls and early-warning systems.

Norway has decided to substantially step up efforts in climate adaptation, resilience and fighting hunger. Supporting risk-informed early action is an important part of this. Norway has for a long time been a political and financial supporter of efforts to strengthen climate services at the national level, through the capacity-building of National Meteorological and Hydrological Services.

We were one of the initiators of the Global Framework for Climate Services, and we are advocating the use of openly available weather and risk information. The Norwegian Meteorological Institute has a free and open data policy and provides free weather information for the whole world. I recommend all of you to download the Yr.no app. Weather and climate services are at the core of anticipatory action, adaptation planning and climate-resilient development – and should serve as a global public good. We are looking forward to seeing how the work of the CTCN will evolve in this area, which is key to increasing the resilience of the most vulnerable.

Gender and climate change

Women commonly face higher risks and greater burdens from the impacts of climate change. Their needs must be addressed to ensure effective and equitable climate change actions. At the same time, women bring new perspectives and innovations in identifying and implementing solutions.

As a member and former Chair of the Advisory Board of the CTCN, I have the strong impression that the CTCN systematically is gender sensitive – in its technical assistance and in relation to partners, publications and other efforts exploring the topic of gender and climate change solutions.

Gender equality is a standalone goal in the SDGs, and at the same time is incorporated across the entire agenda. Tackling climate change demands that everyone's experience and skills are utilised. But technologies are not gender neutral. Therefore, climate technology actions must ensure that both women and men are engaged in decision-making processes, and in the development and use of technologies. And both women and men should benefit from their outcomes. Again, I am pleased to see the CTCN being active and vocal in the inclusion of women and girls.

Future solutions

At the last Advisory Board meeting of the CTCN, the representative of youth organisations voiced their demand to be included in the climate debate. At the UN Climate Summit in September 2019, the voice of youth was indeed present and strong. Regarding technology, the younger generation has a comparative advantage. Future solutions will depend on their education and capacity for innovation. I look forward to following how the UN, regions and countries will include young people's voices.

Finally, I would like to highlight the CTCN's potential to make a difference. Despite its modest annual budget, the CTCN is the gateway to a large network of immensely capable, climate change experts. It also has a vast array of potential clients: it is a body under the UNFCCC serving the Paris Agreement, available to all developing countries.

The CTCN is currently working on 171 projects in more than 90 countries around the world, through its network of more than 500 members in private sector, public sector, academia and other institutions. It has a unique insight into countries' technology needs and has already started work on a multi-country approach. Taking a holistic view on several countries in a region may increase the efficiency of technology transfer and development, for both mitigation and adaptation.

Given the change now underway in how financial institutions include climate change risks, I do believe that the CTCN and its partners will play an important part of the globally needed transformational change. ■

CTCN IN THE DOMINICAN REPUBLIC

Technical assistance for meteorological services

As part of its climate change adaptation activities, the Dominican Institute for Integral Development (IDDI) looked to the CTCN for assistance in developing new technologies to limit the damage suffered from extreme weather events.

The project created a community-based early warning system in high-risk areas of Santo Domingo to alert the population of impending hurricanes.

This included strengthening communications protocols; identifying new technologies (including mobile phone app); and brokering private financing for development and scale-up of communication.

Connecting investors with climate projects

How can we encourage more private investment, particularly to nurture the entrepreneurs in developing countries that will be critical for meeting the climate challenge?

By **Peter Storey**, Founder and Global Coordinator, Private Financing Advisory Network (PFAN)

A rapid scale-up of investment in clean energy generation capacity is required to replace energy generation based on fossil fuels and avoid the worst impacts of climate change. At the same time, significant investment will have to flow towards increasing the resilience of vulnerable populations and helping them to adapt to the changes already here and those still to come. Governments alone will not be able to provide enough investment to achieve the impact required.

As technology prices continue to fall, clean energy projects become more profitable and the appetite of investors for such projects grows. So now is a time of enormous potential for the development of clean energy capacity at scale around the world. Globally, 90 per cent of investment in clean energy generation capacity comes from private sources. But in 2013–15, 93 per cent of this finance went to domestic projects. Despite their often great clean energy generation potential and the significant socio-economic impacts that could be generated, low and middle-income countries (LMICs) receive only a very small fraction of global private investment for clean energy.

> **Now is a time of enormous potential for the development of clean energy capacity at scale around the world**

Unlocking private-sector finance in support of climate action in developing markets is one of the main challenges that governments, international organisations and development banks have been grappling with since the early days of climate change discussions. PFAN has been tackling this challenge since 2006. We have used small amounts of public funding to leverage large amounts of private-sector investment for clean energy and climate resilience projects in LMICs. To date, $1.6 billion has been leveraged for 124 projects since PFAN's inception in 2006.

PFAN has sought to address barriers to large-scale private investment in small and medium-sized enterprises (SMEs) in LMICs' climate-adaptation and clean-energy sectors.

On the supply side, entrepreneurs have difficulty developing solid, investor-ready business plans without outside assistance. This is because SMEs may not have enough knowledge of the language and priorities of (international) investors.

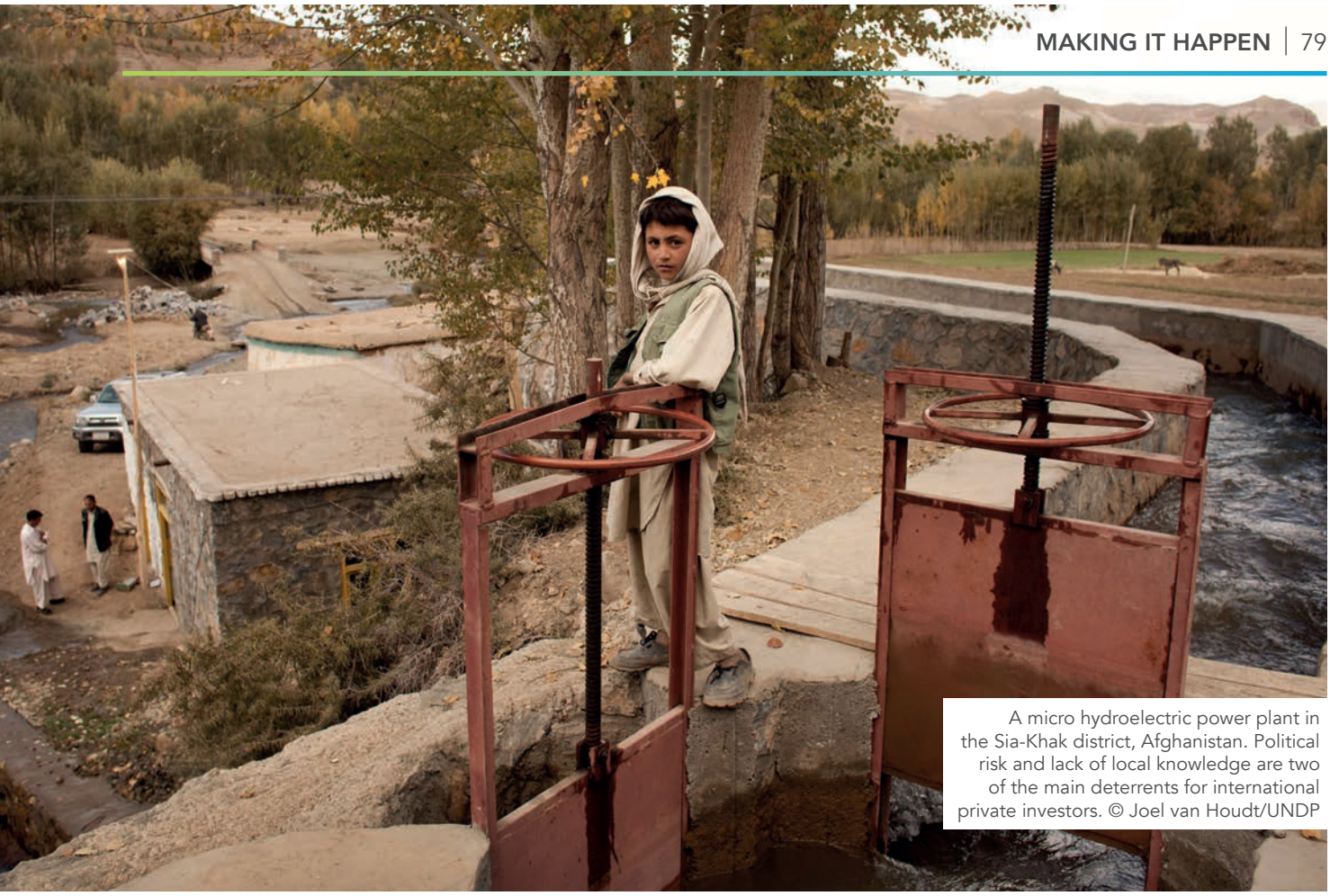
On the demand side, investors find it difficult to assess risks associated with investing in clean energy and climate adaptation businesses in LMICs. Since these businesses tend to offer new technologies in underdeveloped markets, employ innovative business models and depend on shifting regulatory frameworks, only investors with very deep local knowledge would view them as anything but risky.

For 12 years, PFAN has built up a global network of financing experts who have the requisite local knowledge of the markets in which they operate to both coach entrepreneurs and advise investors. Our coaches help SMEs improve their business plans, structure their financial models and clearly define their investment asks, before presenting them to potential investors. Our investment facilitation team helps investors access opportunities that match their interests.

Barriers remain

We have seen enormous growth in clean energy markets worldwide, including large growth in the involvement of the private finance sector. However, a number of significant barriers to the successful financing of clean energy projects still remain:

- Large generation projects, such as wind parks or large solar plants, tend to require high upfront investment and have long payback periods. This makes investments in those projects still high risk, especially in countries with unstable regulatory environments (including, for example, insecurity around land ownership).
- Smaller projects needing smaller investment, conversely, often have difficulty attracting funding as potential investors find the transaction costs for



A micro hydroelectric power plant in the Sia-Khak district, Afghanistan. Political risk and lack of local knowledge are two of the main deterrents for international private investors. © Joel van Houdt/UNDP

due diligence, reporting and foreign currency risk too high.

- Establishing clean energy generation projects tends to take a long time. These projects need regulatory approval, adequate land, and power purchase agreements before they can start looking for private investment. Projects find it difficult to finance these early development phases. While start-up incubators can support early-stage businesses that offer highly innovative solutions, similar facilities tend not to exist for businesses applying proven technology in a new market.
- The operation of on-grid clean energy generation facilities in LMICs tends to be hampered by poor distribution infrastructure. This leads to high transmission and distribution losses and affects generation facilities' bottom line.
- Finally, the speed at which the technology changes, combined with the long lead times, makes investors hesitant. By the time a project is up and running it is often already outdated. It is also anticipated that in the near future, big strides will be made to improve the capacity and affordability of energy storage. This could change the way the clean energy sector functions altogether.

Within the clean energy sector, on-grid solar and wind energy generation have been a favourite of governments because of their affordability, reliability and scalability. Investors have followed suit. Other clean energy sources and applications, such as energy efficiency, biomass and e-transport, vary more in cost per kWh. They are also much more difficult to scale and include more external variables (the sourcing of fuel for biomass plants, for example). These therefore still receive less interest from financiers.

Beyond clean energy and climate change mitigation, private financing for climate change adaptation is still in its infancy. 'Pure' adaptation projects such as climate-proofing of infrastructure or developing coping mechanisms for vulnerable populations are generally the remit of governments or NGOs. But many commercially viable projects, in the clean energy sector and beyond, provide adaptation benefits.

Examples of such projects that have been supported by PFAN include:

- Victoria Seeds, a seed company stocking a new range of fodder seeds, which, together with a change in grazing habits, would allow farmers to increase their herd size, even when experiencing reduced rainfall; and
- the Baobabs, a sustainable housing estate development that restored and protected nearby mangrove forests, close to Pemba in Mozambique.

PFAN aims to make these adaptation benefits explicit. We want to encourage both project developers and investors to consider how they can be maximised in any project they develop or finance.

Between the ever-decreasing price and increasing sophistication of clean energy technology, the rapid development of energy storage, the growing public awareness of the seriousness of the climate emergency and increasing desire for energy independence in many countries, we see no reason why private investment in climate action should not continue to grow rapidly over the coming decades. However, programmes such as PFAN, which offer support to entrepreneurs in LMICs, will remain necessary to ensure that those countries do not miss the financing boat. ■

Case study:

Growing green in Chile

A recent study analysed how sustainable technologies can transform Chile's agriculture sector. What must be done to increase their uptake?

By **Isabel Quiroz**, Founder-Director, iQonsulting

Agriculture is an important contributor to Chile's economy. In 2018 it grew by 5.8 per cent, compared with 4 per cent for the economy as a whole. The sector accounts for more than 10 per cent of Chile's exports and employs 32 per cent of its workforce.

However, agriculture is responsible for 13 per cent of Chile's greenhouse gas (GHG) emissions, from energy used for production. The sector also consumes large amounts of water. Most agrifood producers in Chile are micro, small and medium enterprises (MSMEs). And while Chile has had clean production agreements in place for many years, the take-up of climate technologies among agrifood MSMEs in Chile has been low. This is affecting these companies' competitiveness.

Chile's Agency for Climate Change and Sustainability therefore asked the Climate Technology Centre and Network (CTCN) for technical assistance to evaluate the main obstacles to investing in climate technologies facing the country's agrifood MSMEs. CTCN commissioned The Carbon Trust, based in England, and iQonsulting of Chile to conduct the study, which would form part of the Chilean state's programme to cut emissions by 30 per cent between 2017 and 2030, reduce poverty and inequality, and move towards development that is low carbon, sustainable, competitive and inclusive. The Sustainable Development Goals

Los Lagos region, Chile, a priority region for the study. © Joe Dunckley/Alamy Stock Photo

(SDGs) addressed in the study are SDG 8 (decent work and economic growth), SDG 9 (industry, innovation and infrastructure) and SDG 13 (climate action).

Under the overarching objective of determining barriers to investment, the specific objectives were:

- map the country's agrifood chain, identifying points in the production process that justify investment in technologies to help reduce GHG emissions and promote climate change adaptation;
- evaluate how effective Chile's National Council for Clean Production instruments have been in removing non-financial barriers and hence, improving uptake of climate technologies and competitiveness among MSMEs;
- make recommendations for improving these instruments;
- analyse current national and international funding instruments and their effectiveness for promoting clean technologies among MSMEs;
- propose funding instruments for agrifood MSMEs to allow adoption of climate technologies and improve the sustainability of the sector.

Chile's production development corporation CORFO estimates that adoption of climate technologies in the agricultural sector could cut CO_2 emissions by 18.4 million tonnes. The study will help Chile to achieve this through:

- strengthened local institutional capacity, so that authorities can replicate learnings to other agri-chains (and potentially other sectors), catalysing further sustainable growth within Chile's MSMEs;
- recommendations to inform the implementation of a Green Investment Bank, which is being developed in parallel to this study;
- recommendations to help facilitate the integration of the agricultural sector as a priority sector for the banks.

Developing the study

We developed the study in several stages:

1. Prioritise agricultural chains: we identified those chains that had the greatest contribution to GDP, high concentration of MSMEs, and high level of emissions, energy use or water consumption. The prioritised chains were: beef, cows' milk, annual crops, fruit trees, vineyards and vegetables.

2. Prioritise regions with high concentration of the selected chains: Metropolitan, O'Higgins, Maule, Bio Bio, Araucanía, Los Lagos and Los Ríos.

3. Select clean climate technologies and supply chains: for this, we surveyed the prioritised agricultural chains. More than 100 technologies were identified and 23 were prioritised as easy to implement as well as having a high level of development in Chile. The 23 were divided into general technologies and others assigned to a specific agri-chain. They were:

Technologies applicable to all chains

1. efficient lighting systems;
2. efficient ventilation systems;
3. speed variator;
4. water heating with solar energy;
5. biodigesters;
6. biogas;
7. automation and synchronisation of conveyor belts;
8. photovoltaic solar energy;
9. energy economisers;
10. biomass for burners.

Technologies applicable to bovine chains

11. bio-secure livestock transport.

Technologies applicable to dairy cattle

12. pre-chillers;
13. cooling heat recovery units.

Technologies applicable to Agro chains

14. drip irrigation;
15. spray and micro spray;
16. gravity irrigation systems;
17. automation: programmers;
18. irrigation;
19. multi-spectral vision analysis;
20. telemetry (used in precision agriculture).

Specific technology for vegetables and cereals:

21. radiative gas dryers;
22. solar drying tunnel;
23. use of solar energy for air drying.

4. Identify drivers for technological change: we selected three to study in depth: i) clean-production agreements; ii) energy price reduction through the introduction of non-conventional renewable energy (NCRE); and iii) local and international demand pressure to improve standards.

5. Identify financing options for new technology: we analysed financing from government programmes, such as FOGAPE (Small Business Guarantee Fund) and FOGAIN (General Investment Guarantee Fund). We also analysed private financing for MSMEs from banks and financial institutions. The analysis included benchmarking with several countries in Europe, Canada, China and Colombia. We analysed many aspects, focusing on:

i. Guarantees required in bank loans for SME technology financing. Chile is above average in the level of guarantees required: 68 per cent compared with the average of 52 per cent.

ii. Interest rates for MSMEs. Interest rates in Chile have fallen over the last five years. However, rates in Chile are still above the average (only surpassed by Colombia).
iii. Difference between interest rates for MSMEs and large companies. Of the countries analysed, Chile has the greatest difference in rates. This must be improved if we are to promote the incorporation of clean climate technologies in agricultural MSMEs in Chile.
iv. Growth in new financial products or financing options. Chile has a low rate of innovation in financial products.
v. Factorisation volume. Chile has declining rates for factorisation, contrary to the trends in other countries.

> **There are clear financial incentives for farmers who switch to more sustainable cultivation techniques**

6. Identify barriers to the adoption of clean technologies by MSMEs: we grouped these into four categories:

Knowledge barriers
i. Lack of knowledge to assess the financial viability of climate technology projects and clean low-investment technologies;
ii. Ignorance of benefits versus investments costs in clean technologies;
iii. Lack of equipment suppliers with a local understanding;
iv. MSMEs do not know the technologies, doubt performance claims and are wary about technical support.

Technical barriers
i. The main one is the low development of equipment and service providers.

Financial resource barriers
i. Limited available capital for energy management.
ii. High costs per individual transaction.
iii. Lack of access to loans with favourable conditions for MSMEs to invest in clean technologies.

Barriers of commitment
i. Requirement for concrete actions.
ii. Insufficient collaboration and leadership.
iii. Insufficient policies that regulate or encourage clean technologies.

7. Develop solutions to remove the barriers: among the possible solutions agreed with the industry are:
i. Complementing traditional credits with more tailored solutions such as factoring, leasing and crowdfunding.
ii. Promote government-backed transition programmes and aggregation to commercial banks.
iii. Promote education programmes in various technologies and forms of financing.
iv. Promote aggregation solutions at three levels: technology fairs, imports and financing.
v. Certification of prioritised technologies.

8. Identify how to ensure long-term uptake of clean technologies: the necessary actions are framed in public interventions and promote a long-term self-sustainable approach:
i. Involve more private capital (commercial banks and other investors) to generate change at scale. This could include using more alternative funds compared with traditional loans. The sector could learn about the amplifying effect of the Fund for Non-Conventional Energy and Efficient Energy Management (FENOGE) and seek to replicate it.
ii. MSMEs and suppliers to take a more active role in obtaining alternative funds for technical assistance and financing (such as international funds directed to technological suppliers and agro MSMEs).
iii. Workshops to demonstrate new technology for the prioritised sectors of agriculture. These should involve institutions such as The Office of Agricultural Studies and Policies (ODEPA), the Institute of Agricultural Development (INDAP), unions and regional ministerial secretariats.
vi. Technical support for aggregation solutions at three levels (MSMEs, suppliers and financing). This could include:
- alternative financing such as crowdfunding, leasing and international funds (aimed at MSMEs and suppliers);
- technology fairs for MSMEs;
- tenders (focused at MSME associations);
- aggregation of imports (focused at suppliers).

vii. Map the current Clean Production Agreements (Acuerdos de Production Limpio, APLs) that are related to prioritised climate technologies.
viii. Explore the potential of integrating the prioritised climate technologies into the goals of the APLs.
ix. Promote greater coordination between the extension programmes of INDAP and the Agency for Sustainability and Climate Change (ASCC).
x. The ASCC must report on regional adaptation programmes on prioritised climate technologies.
xi. Promote coordination with the potential Chilean Climate Green Bank (Banco Verde del Clima de Chile) to create and finance a portfolio of climate technology projects.

This study made it possible to evaluate obstacles and propose a methodology to study other productive chains with a high proportion of MSMEs.

The study is now in the hands of the sustainability agency and is part of the inputs for studies in other areas of the economy.

Although the sector generates GHG emissions, it also has huge potential to reduce them. There are clear financial incentives for farmers who switch to more sustainable cultivation techniques and introduce climate technologies on their land.

With a wide array of potential mitigation measures at its disposal, the agricultural sector should play a full role in Chile's contribution to halting global warming. ■

Climate Change Strategies 2020

The Climate Technology Centre and Network (CTCN) promotes the development and transfer of environmentally friendly technologies for energy-efficient, low-carbon and climate-resilient development.

The CTCN matches developing country needs for technology equipment, techniques, practical knowledge and skills with the world-class expertise of its global Network of over 500 academic, civil society, finance, private sector and research institutions to deliver tailored technical assistance, capacity building, and knowledge sharing.

The CTCN is delivering technology assistance in 93 countries on a broad range of sectors, including agriculture, energy, industry, transport, water and waste management.

The CTCN is the implementation arm of the United Nations Framework Convention on Climate Change Technology Mechanism, and is co-hosted by the UN Environment Programme and the United Nations Industrial Development Organization.

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CTCN
CLIMATE TECHNOLOGY CENTRE & NETWORK

Climate Change Strategies is a new, annual publication designed to highlight the role of technology transfer in the fight against climate change. The Climate Technology Centre and Network (CTCN), created by the UN system to achieve this task, is the natural focal point. We hope that this publication will help give a better understanding of the urgency and significance of its mission, and encourage all with an interest in this field to engage with the Network. If you provide relevant services or require technical assistance, please don't hesitate to make contact.

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This publication is sustainably produced and carbon neutral, with all emissions that we couldn't avoid, being offset.

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