CLIMATE 2020
Degrees of devastation

UNA-UK

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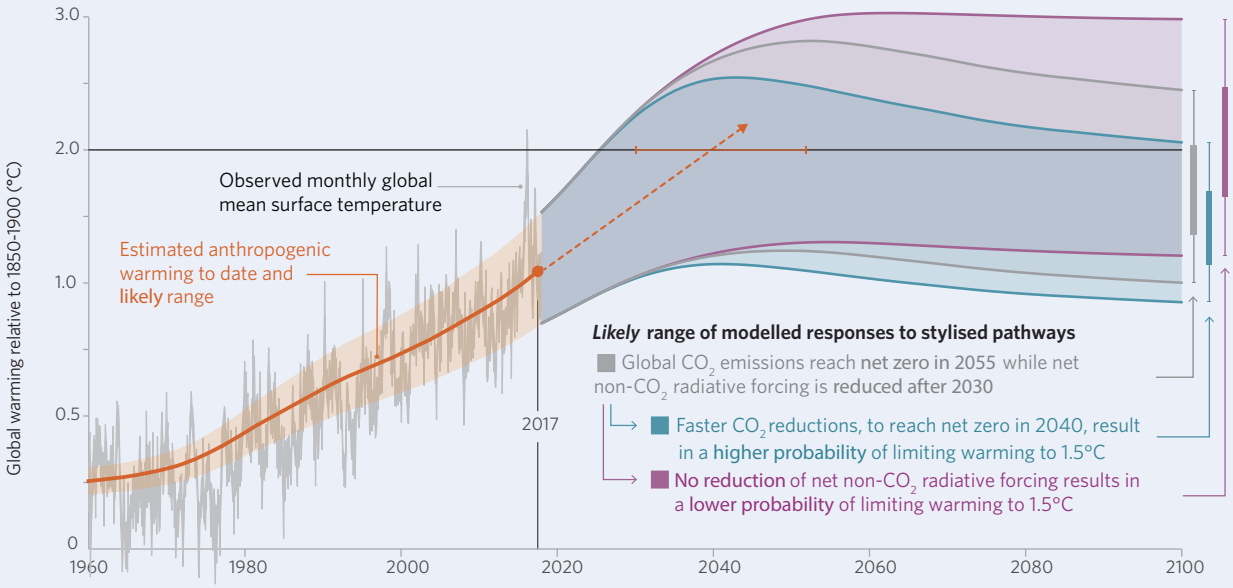
WHERE WE ARE NOW

Cumulative emissions of CO_2 and future emissions of other greenhouse gases will determine the chances of limiting warming to 1.5°C

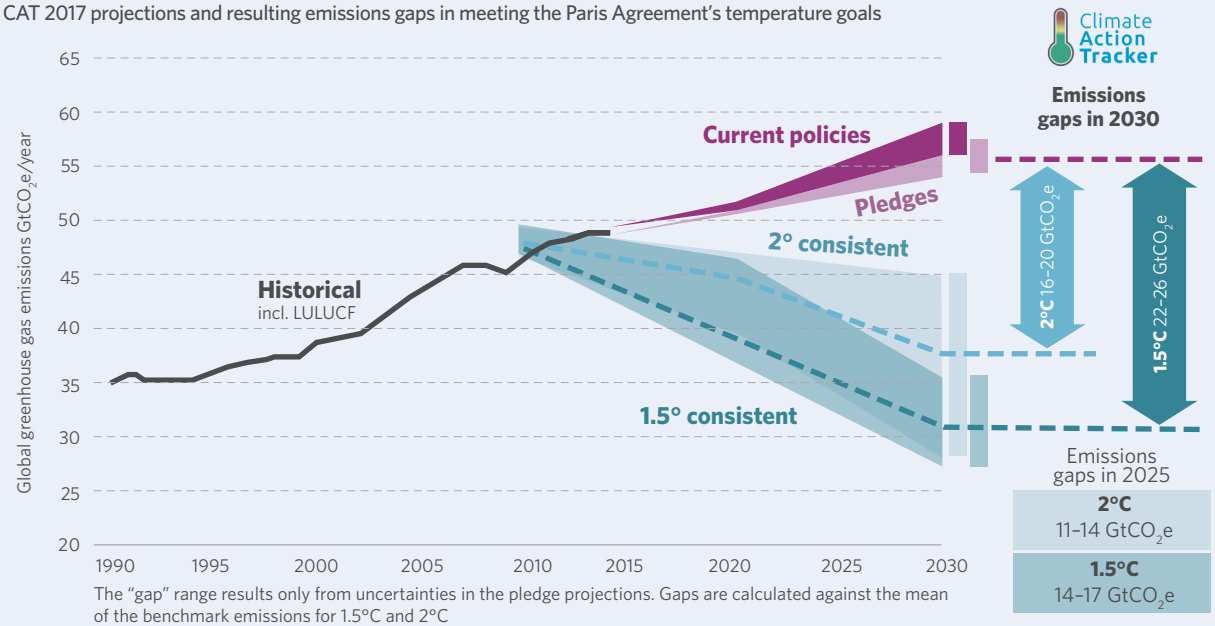
Observed global temperature change and projected outcomes in response to different emission reduction scenarios



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

2030 emissions gaps

CAT 2017 projections and resulting emissions gaps in meeting the Paris Agreement's temperature goals



The "gap" range results only from uncertainties in the pledge projections. Gaps are calculated against the mean of the benchmark emissions for 1.5°C and 2°C

We cannot ignore climate risk

To limit global warming to 1.5°C we will need fundamental shifts in our economic and financial policies – by 2020

By **António Guterres**,
Secretary-General, United Nations

The Paris Agreement calls for governments to keep global temperature rise to well below 2°C and as close as possible to 1.5°C. We are way off target.

Climate change is running faster than we are. The commitments made so far by parties to the Paris Agreement represent just one third of what is needed. We risk irreversible catastrophe if we don't act more quickly and with more ambition.

◀ UN Secretary-General António Guterres meeting residents in Mopti, Mali. Like other countries in the Sahel, Mali is acutely experiencing the impacts of climate change, suffering frequent droughts and the consequential instability and conflict

The world has already warmed by one degree. We are already seeing the consequences for people, economies and ecosystems everywhere.

The special report released by the Intergovernmental Panel on Climate Change (IPCC) in October is clear. Limiting global warming to 1.5ºC is still possible and will prevent some of the worst-case scenarios. To limit warming to 1.5ºC, greenhouse gas emissions must come down by 45 per cent by 2030 and reach net zero by 2050. To achieve that, we absolutely must bend the emissions curve by 2020.

As the IPCC stressed, limiting temperature rise to 1.5ºC will require rapid, far-reaching and unprecedented changes in all aspects of society – especially how we manage land, energy, industry, buildings, transport and cities. That means ending deforestation and planting billions more trees. It means drastically reducing the use of fossil fuels and massively increasing renewable energy. It means switching to climate-friendly sustainable agriculture. And it means considering new technologies, such as carbon capture and storage.

Achieving this will require three key shifts. First, we need a new economic framework that integrates climate and disaster risk in all aspects of finance, planning and budgeting.

Last year, the economic costs of climate-related disasters hit a record $320 billion. By 2050, climate change could reduce annual GDP in some countries in South and Southeast Asia by up to four per cent. We cannot afford to ignore climate risk.

Second, we need effective economic policy and fiscal instruments. We need to put a meaningful price on carbon and end fossil fuel subsidies, which today amount to $373 billion a year.

Carbon pricing and ending fossil fuel subsidies can promote the low-carbon and climate-resilient growth we need. Carbon taxes or emissions trading systems are now in place or planned in 70 jurisdictions worldwide. But this coverage amounts to only one fifth of total global emissions. According to the 2018 New Climate Economy report, carbon pricing and ending subsidies could generate nearly $3 trillion in government revenues or savings by 2030.

Third, we need fundamental shifts in climate financing. We need to turn global investment in climate action from billions to trillions. The money is there but the policies that will liberate it are weak or non-existent. Mobilising private sector financing is essential. But public financing and policies need to provide the foundation for the private sector to embrace climate action. Governments need to encourage their banks to support green financing and innovative financial instruments – such as green bonds – and debt instruments that can strengthen the resilience of vulnerable nations.

We need to see the Green Climate Fund become fully resourced and operational. It is also essential that governments fulfil their pledge to mobilise $100 billion a year by 2020 for climate action. In this regard, President Emmanuel Macron of France and Prime Minister Andrew Holness of Jamaica have accepted my invitation to co-chair an initiative to support a political process to meet this pledge.

Finally, we need to avert investment decisions in infrastructure and agriculture that would lock in irreversible, high-carbon, unsustainable development. Some $90 trillion of infrastructure investment is expected by 2030. It needs to be climate friendly.

The next few years are critical. Next September, I will convene a Climate Summit to mobilise action and enhance ambition. We have six areas of focus: energy transition; industry transition; resilience; local action and cities; finance and carbon pricing; and nature-based solutions. We need to show that countries and businesses are putting in place the policies and instruments that we need.

Between now and then, we have COP24 in Katowice in December – this year's session of the annual UN climate negotiations. It is important that this meeting is a success. We cannot afford another Copenhagen.

We need to come out of the meeting with a robust framework that allows countries to operationalise and implement the Paris Agreement. The negotiations will require strong and visionary leadership from around the globe.

I encourage all to engage in moving these critical issues forward. ●

This article is taken from remarks made by the Secretary-General at the Climate Finance Ministerial Meeting on 13 October 2018.

We need more cooperation, not less

The global risks facing the world are complex, catastrophic and already upon us. We must adopt radical solutions to improve our ability to address them

By **László Szombatfalvy**, Founder and Chairman, Global Challenges Foundation

Stopping climate change is going to be an uncertain fight against the clock. That so many states were in agreement both on the Sustainable Development Goals and on the measures that were adopted in connection with the Climate Change Conference in Paris in 2015 raised the hopes of many, even though the commitments were inadequate and non-binding. Implementation seems even shakier. What is certain in the short term is that the unanimity of the Paris Agreement has partly been broken by the USA's decision to withdraw from it. The uncertainty concerning future measures against climate change has increased.

This is why I welcome the initiative by the United Nations Association – UK (UNA-UK) in publishing this comprehensive report on climate risk. What we need today is more cooperation, not less, at the global level. We need to find, test and improve every conceivable idea that could lead to the creation of better and more robust systems for dealing with the largest global threat to humanity.

Most climate news is negative and suggests that the risks are greater than previously imagined. A newly presented research report, *Trajectories of the Earth System in the Anthropocene* by Will Steffen, Johan Rockström, Katherine Richardson et al., states that even at 2°C of global warming we could exceed a "planetary tipping point" that will lead to self-reinforcing global warming. This could turn our planet into a "Hothouse Earth", which would mean a future with even higher temperatures and even more intractable global environmental risks.

Given that global public opinion almost unanimously regards climate change as the greatest threat to humanity, it is even more perplexing that we have not done more to minimise climate risk.

I believe that part of the explanation lies in the complexity of the problems we need to solve. The climate issue may be the most well known and analysed of the major global risks. But there are a number of other threats revolving around climate risk, connected to and often reinforcing the climate threat, or preventing or delaying essential action. There are also the risks of politically motivated violence and weapons of mass destruction. These firstly draw attention away from more long-term problems, and secondly poison the relations between states and ethnic groups, thereby impeding the cooperation necessary to counteract global risks.

- The worse catastrophes are only expected to occur several decades or more into the future – so some conclude that there is no hurry.
- Politicians are busy solving shorter-term, local problems, being accountable to their constituents in the next general election.
- Many politicians do not think that the general public is prepared to make short-term sacrifices to tackle the climate threat in the long run.

Global risks do not respect national borders. One country's emission of greenhouse gases impacts the entire global climate. For this reason, global risks should be dealt with by means of an overarching plan

Furthermore, there is the risk of major environmental degradation that threatens to deplete our ecological systems. On top of this, extreme poverty in many countries, coupled with climate change and explosive population growth, may lead to uncontrolled migration, which could generate and prolong wars and political violence. Population growth in itself arguably slows down the effects of action on climate change, particularly in the long run.

Other factors contribute to our paralysis in connection with the climate problem:

On the last matter, I believe that politicians have misjudged the situation. Our organisation, the Global Challenges Foundation, has commissioned several international opinion polls to determine global attitudes towards major global risks. From the latest survey, conducted in the spring of 2018 in 10 different countries (Australia, Brazil, China, Germany, India, Russia, South Africa, Sweden, the UK and the USA), it is clear that a qualified majority of respondents are already prepared to make "considerable sacrifices" to try to prevent extreme climate catastrophes – even if they may occur in several hundred years' time.

Global risks do not respect national borders. One country's emission of greenhouse gases impacts the entire global climate. For this reason, global risks should be dealt with by means of an overarching plan that has the whole of humanity's best interests at heart, and that also takes future generations into consideration. This

▲ A public cemetery in Semarang, Indonesia, strewn with seaborne garbage. Indonesia, as an archipelago of more than 17,000 islands, is particularly vulnerable to rising sea levels

'long-term' problem is in fact so urgent that unconventional and radical solutions are acutely necessary. It stands to reason that the management of these major global risks – and the powers to do so – should be entrusted to a neutral global organisation, such as an empowered and strengthened United Nations or a new body.

International cooperation

In my opinion, there is really no conflict between independent national states and a global organisation that is granted executive authority and enforcement powers in relation to a strictly limited number of well-defined problems. According to the aforementioned opinion poll, the majority of people – nearly 70 per cent – in those countries are in favour of such a solution. Only 19 per cent are against, while 11 per cent are uncertain. This indicates that in spite of recent nationalistic and populist trends, most individuals are actually in favour of international cooperation on such challenges.

The Foundation recently conducted a competition in which we invited thinkers from every corner of the world to formulate a decision-making model that could better manage the most catastrophic risks in a more effective and equitable way than today. Out of 2,700 submissions from 122 countries, we chose to award prizes to three proposals. Five working groups are now, with support from our foundation, working on different models, in order to present even better solutions in connection with the Paris Peace Forum in November 2018.*

I hope that this report will be read by many decision-makers within politics, business and civil society, with a view to learning more about the risks that threaten us both in the short and long term.

Let us also use this as a starting point for reflecting on how we can create a better and safer world together – before it is too late. ●

** Natalie Samarasinghe, Executive Director of UNA-UK, was one of the three prize recipients and is now coordinating one of the five working groups. More information is available at www.una.org.uk*

Half a degree, half a chance

The latest IPCC report outlined the devastating impact of a 2°C temperature rise – the Paris target that we're set to miss spectacularly – against the somewhat less bad scenario of 1.5°C. We are now in damage limitation mode, and the window for doing even that is closing fast


© Andrew Burton/Getty Images

◀ **Children of the Yupik tribe in Newtok, Alaska. Rising temperatures are melting the permafrost, widening the rivers and eroding the coastline. The tribe has made a disaster declaration to the US government, requesting assistance in relocating**

By **Natalie Samarasinghe**, Executive Director, United Nations Association – UK

2018 may well be remembered as the year we missed the opportunity to prevent the worst impacts of climate change. In October, the Intergovernmental Panel on Climate Change (IPCC) released a special report on the differences between a world that is 1.5ºC warmer than pre-industrial levels, and one where temperatures are 2ºC higher. It is a grim read.

That crucial half a degree would add 10cm to global sea level rise, putting 10 million more people at risk. It would wipe out virtually all coral reefs. Three times as many insects, and twice as many plants and mammals, would lose over half their living space. Nearly 120 million more people would experience water scarcity. Two times as many people would be exposed to extreme heat. The average drought would last twice as long.

Even the dense and cautious language (projections are given a confidence level and a likelihood rating, where "likely" is classified as having a 66 per cent to 100 per cent chance of occurring) is unable to soften the fact that we are now in damage limitation mode. In 2015, global warming reached 1ºC and our options going forward all entail significant upheaval and loss of life.

Given the enormous risks involved, it is astounding that climate change does not dominate the headlines, or play a central role in elections and investment decisions

The 1.5ºC scenario may be better, but it does not avoid sea-level rise, habitat loss and longer droughts. It would still see coral reefs decline by 70-90 per cent and millions of people struggling to cope with multiple challenges such as crop failures and extreme weather.

Current projections put us on course to reach this point in the next 10 years or so. It is this context that makes the report so distressing. Given that the 1.5ºC scenario, included in the Paris Agreement as an "ambition" at the insistence of small island states and a few others, is so disruptive, the 2ºC target that world leaders agreed seems woefully inadequate. More worryingly, we are nowhere near meeting even that goal. If all commitments made under Paris were realised, global temperatures would rise by 2.6-3.2ºC. Our present trajectory puts us on track for a 3.1-3.7ºC rise – and we know what a deadly difference half a degree can make.

Turning point?

But there is still a chance that 2018 will come to be seen as the year the world changed course. The IPCC's report sets out pathways for how we can limit global warming to 1.5ºC with no or minimal overshoot of this target. It features different combinations of lowering energy demand and consumption and moving to low-carbon goods and services, as well as strategies for removing carbon dioxide – recognising that whatever we do now, we will need to take CO_2 out of the air in addition to reducing emissions.

One of the best-case scenarios is based on us achieving rapid decarbonisation, with afforestation being used to balance remaining emissions by removing CO_2. A middle-of-the-road scenario projects societal and technological developments following historical patterns, which would require more intensive changes in the way energy and products are produced, to compensate for a less steep reduction in demand. The least-promising scenario, which would see a higher overshoot of the temperature target, sees us continuing energy-intensive growth, and therefore being heavily reliant on carbon removal technologies – most of which are still untested, especially at scale.

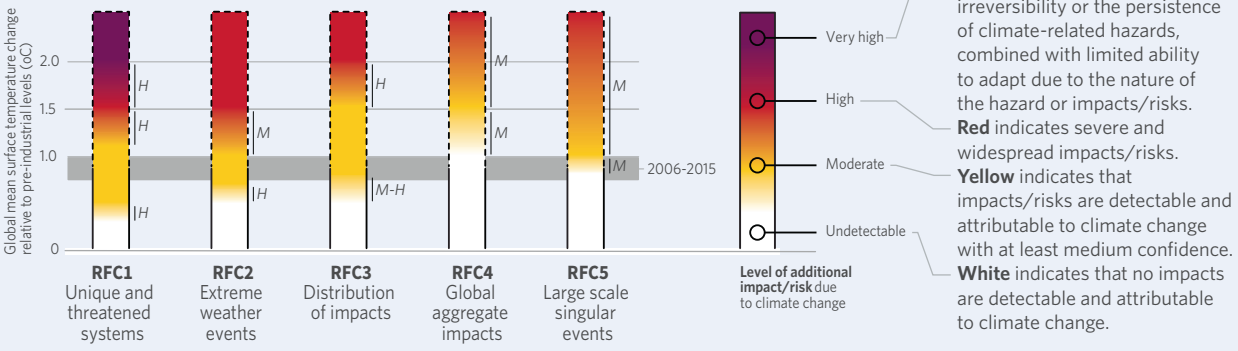
The message is clear: somehow, we need to halve net emissions in the next 15 years or so and virtually eliminate them by 2050. In parallel, we need to improve low-carbon technologies and carbon removal strategies dramatically. As IPCC member Jim Skea notes: "Limiting warming to 1.5ºC is possible within the laws of chemistry and physics but doing so would require unprecedented changes."

This publication features strategies and case studies for how we can meet this challenge through rapid, far-reaching transformations in areas from food to

How the level of global warming affects impacts and/or risks associated with the Reasons for Concern (RFCs) and selected natural, managed and human systems

Five Reasons For Concern (RFCs) illustrate the impacts and risks of different levels of global warming for people, economies and ecosystems across sectors and regions.

Impacts and risks associated with the Reasons for Concern (RFCs)



Purple indicates very high risks of severe impacts/risks and the presence of significant irreversibility or the persistence of climate-related hazards, combined with limited ability to adapt due to the nature of the hazard or impacts/risks.
Red indicates severe and widespread impacts/risks.
Yellow indicates that impacts/risks are detectable and attributable to climate change with at least medium confidence.
White indicates that no impacts are detectable and attributable to climate change.

RFC1 Examples include coral reefs, the Arctic and its indigenous people, mountain glaciers, and biodiversity hotspots.
RFC2 Heatwaves, heavy rain, drought and associated wildfires, and coastal flooding.
RFC3 Risks/impacts that disproportionately affect particular groups due to uneven distribution of physical climate change hazards, exposure or vulnerability.
RFC4 Experienced on a global scale: monetary damage, environmental degradation and loss of ecosystems and biodiversity.
RFC5 Abrupt and sometimes irreversible changes in systems that are caused by global warming. Examples include disintegration of the Greenland and Antarctic ice sheets.

Source: IPCC Special Report on Global Warming of 1.5°C

fuel, from cities to coastal communities. It is hardly an easy to-do list. Indeed, our contributors make clear that our approach cannot be linear and compartmentalised: number one, save humanity; number two, deal with human rights, conflict, etc.

Our success on the first goal is predicated on progress towards the second. We have to stop using fossil fuels, for example, but we can't get there without ensuring that those whose livelihoods depend on it, and those who have no other option, are able to survive.

That does not mean we have to wait for the perfect solutions to move forward. In 2015, UNA-UK cast aside its reservations about the Paris Agreement on the basis that it represented a much-needed, long-overdue starting point from which to ratchet up ambition. But we cannot afford to put off the difficult decisions involved with fundamentally changing our societies. For this reason, we have chosen to put special emphasis on finance in this publication, and give top billing to UN Secretary-General António Guterres, who succinctly sets out the fundamental economic shifts we need to start instituting now, and to László Szombatfalvy, the billionaire investor and philanthropist, whose risk-based framing of climate change will resonate both with business and the public at large.

Every day counts

Given the enormous risks involved, it is astounding that climate change does not dominate the headlines, or play a central role in elections and investment decisions. Astounding too is the prevailing wisdom that we must not be too gloomy in our messaging for fear of putting people off.

Of course, we should highlight the practical actions and policy changes that people can take and support. But it is difficult to think of another issue where we so easily underplay the grave dangers we face. If someone tells you that your house is burning, does that make you less likely to try to put out the fire?

In any case, we are now entering a period where those in the West, and elites in the South, are beginning to see what the poor and vulnerable have known for decades – that climate change is here. The past months have seen a heatwave contribute to an estimated 250 deaths in just one night in the UK. The US has been repeatedly battered by hurricanes, and forest fires in countries such as Greece have hit the tourism industry, affecting rich and poor alike. We have also seen an increase in warnings about the impacts of climate change on beer, for instance, which appear to have reached an audience far beyond the usual suspects.

Whatever the reasons, UNA-UK hopes this will be the year we all finally woke up to climate change. Every day matters now. We need to act fast. ●

A holistic approach to climate action

The Dubai Electricity and Water Authority (DEWA) demonstrates its commitment to mitigating climate change throughout its operations to fulfil Dubai's energy and water needs. DEWA's flagship plant, M-Station, epitomises this approach

M-Station is the largest power production and desalination plant in the United Arab Emirates (UAE), with a current total capacity of 2,185 megawatts (MW) of electricity and 140 million imperial gallons per day. How is it helping to tackle climate change?

M-Station is a national landmark that adds to DEWA's growing list of achievements over the last five decades. It was inaugurated in Jebel Ali Power Station in April 2013 by HH Sheikh Hamdan bin Rashid Al Maktoum, Deputy Ruler of Dubai, Minister of Finance and President of DEWA.

M-Station adopts the highest levels of availability, reliability and efficiency, using the most advanced technologies in the world. It is equipped with the latest smart devices and sophisticated heavy-duty technological systems.

An expansion project – adding 700 MW to M-Station's installed generating capacity – is due to be completed in 2018. The project includes the addition of two dual-fuel gas turbine generators, two heat recovery steam boilers, and one steam turbine with 90 per cent fuel efficiency. This will increase the plant's thermal efficiency from 82.4 per cent to 85.8 per cent – one of the highest thermal efficiency rates in the world.

Installing PV panels at the M-Station

The M-Station is currently being upgraded to make it one of the most thermally efficient power plants in the world

DEWA has succeeded in enhancing the efficiency of fuel use to between 84 and 90 per cent, while improving production efficiency by 25.47 per cent in 2016 compared to 2006. This is through the deployment of highly efficient technologies in the production of electricity, and water desalination.

How does DEWA integrate energy management into its premises?

In 2013, DEWA opened its Sustainable Building in Al Quoz. It is the first sustainable government building in the UAE, and the largest government building in the world to receive a platinum rating for green buildings from LEED (Leadership in Energy and Environmental Design). The building uses 66 per cent less energy than a traditional building, and includes an on-site 660 kilowatt (kW) solar power plant. It also reduces water consumption by 48 per cent. In addition, 36 per cent of the materials used to build it came from recycled sources.

DEWA has also launched a number of initiatives to enhance the efficient use of power and water. Through these initiatives, the annual per capita consumption of electricity and water has been reduced from 13,626 kWh and 38,554 imperial gallons (IG) in 2015 to 12,826 kWh and 36,391 IG in 2016.

DEWA has implemented many conservation measures, such as housekeeping changes, in five of its buildings. As a result, between 2013 and 2016 we achieved savings of 19 per cent for electricity and 52 per cent for water, amounting to 4.6 million dirhams (AED).

In April 2016, DEWA inaugurated one of the largest single-rooftop arrays in the Middle East and North Africa – a 1.5 MW direct current photovoltaic (PV) generation project at Jebel Ali Power Station – and successfully connected it to DEWA's grid. DEWA installed 5,240 PV panels on the roof of the water reservoir at the M-Station. The modules convert solar energy into electricity, which will be used to meet the station's energy needs and will generate 2,666 MWh of clean electricity annually. The project aims to preserve the environment and reduce CO_2 emissions by about 1,500 tons annually. ■

هيئة كهرباء ومياه دبي
Dubai Electricity & Water Authority

UNA-UK thanks DEWA for its generous support for this publication

© Joerg Boethling/Alamy Stock Photo

Women and climate action

Women and girls bear the brunt of the impacts of climate change. Empowering women to fulfil their potential must therefore be at the heart of adaptation strategies

By **Phumzile Mlambo-Ngcuka**,
UN Under-Secretary-General and
Executive Director, UN Women

Climate change and gender inequality are arguably two of the greatest sustainable development challenges of our time. Climate change affects the entire planet and all peoples, although not in the same way or to the same degree. Gender inequality, meanwhile, denies full human rights to half the population and fuels discrimination and violence. The key to tackling both issues effectively is understanding the many ways in which they are interlinked.

The impacts of climate change affect the livelihoods and wellbeing of both women and men – with impacts on agricultural production, food security, health, water and energy resources, climate-induced migration and conflict, and climate-related natural disasters. But because climate change amplifies existing gender inequalities, these impacts are felt differently by women and men. Often, women and girls are the last to eat or be rescued. They face greater health and safety risks as water and sanitation systems become compromised. And they take on increased domestic and care work as resources dwindle. Poverty, meanwhile, leads to earlier marriages, lost education and diminished opportunities.

Women and girls typically carry a disproportionate burden of unpaid care and domestic work, and this only increases with a changing climate. For example, women and girls are responsible for water collection in 80 per cent of households without access to piped water. Climate-induced drought and scarcity also affect the time and effort required to collect, secure, distribute and store water, fuel and other resources.

Where access to clean and affordable energy is lacking, women and girls may spend large portions of their day performing laborious and physically draining tasks such as collecting biomass fuels and manually processing foodstuffs. In areas of fuel scarcity, fuel collection can take up to five or six hours per day – time that could otherwise be used for paid work, education, rest or leisure.

Recognising these conditions is crucial, as is recognising that women are not naturally a 'vulnerable group' but may become so through the contexts in which they live and move. Characterising women consistently as vulnerable marginalises their participation in climate change mitigation and adaptation, and omits or diminishes the many strengths and solutions they bring.

For instance, women's participation and leadership are key to: accelerating the adoption of renewable energy technologies and climate-smart agricultural practices; promoting sustainable transport and urban

◀ **Burkina Faso, women making shea butter using traditional methods. A UN Women initiative in the Ivory Coast has improved manufacturing processes, which reduces labour intensity and opens access to higher-value markets. In turn, its success is providing protection against deforestation and is economically empowering the women**

Also in this section

development; and reducing and responding to climate-related disaster risks. This contribution must be fully recognised, measured and supported.

Through their experiences as early adopters of many new agricultural techniques, first responders in crises, entrepreneurs of green energy and decision-makers at home, women offer valuable insights and solutions into better managing the climate and its risks.

Women can also help to address climate change at scale. They are key actors in building community resilience and responding to climate-related disasters. Women tend to make decisions about resource use and investments in the interest and welfare of their children, families and communities. And, as economic and political actors, women can influence policies and institutions towards providing more public goods that both support climate resilience and disaster preparedness and tend to matter more to women. These include energy, water and sanitation, and social infrastructure.

At UN Women we have been working to address climate change and gender equality on a number of levels. Together with partners from the United Nations system, national governments and civil society, UN Women supports the negotiations of the UN Framework Convention on Climate Change (UNFCCC) to integrate gender equality dimensions in climate change decisions and policies. For example, at COP23 in November 2017, we supported the establishment of a Gender Action Plan.

Enacting good policies requires quality data, so that we can quantify the issue and measure improvement. UN Women's recent report, *Turning promises into action: Gender equality in the 2030 Agenda for Sustainable Development*, tracks progress towards the Sustainable Development Goals (SDGs) from a gender perspective, including climate-relevant SDGs (SDG 13 on climate action, SDG 14 on life below water and SDG 15 on life on land).

An examination of these goals reveals that statistics on the gender effects of climate change, as well as management of natural resources on which women's livelihoods heavily depend, are largely missing. The report stresses that improved sex-disaggregated data on asset ownership and the use of environmentally friendly technologies needs to be given high priority when monitoring efforts to better understand women's needs and promote women's agency in climate action.

UN Women is also addressing the nexus of gender equality and climate change through three flagship programming initiatives, in conjunction with partners and stakeholders at global, national and local levels. These cover the critical areas of sustainable energy, climate-smart agriculture and community resilience to natural hazards in a changing climate, and are aligned with a number of SDGs.

Systematically addressing gender gaps in responding to climate change is one of the most effective mechanisms to build the climate resilience of households, communities and nations, and to ensure that no one is left behind

Empowering women in Côte d'Ivoire

An example of UN Women's work on the ground in climate-smart agriculture is a joint programme with the government of Côte d'Ivoire in the shea sector. The programme provides a climate-smart solution to reducing deforestation, while bolstering rural women's economic empowerment.

In the West African country, women make up almost 70 per cent of the agricultural labour force. But only three per cent of women own the land that they cultivate. The country also ranks as the fifth-largest producer of shea butter, which is extracted from the nuts of the African shea tree and widely used in cosmetics.

Producing shea butter is largely seen as a woman's job, and it is no easy task. Since the traditional method used to produce shea butter is labour-intensive, and the resulting product does not necessarily meet international quality standards, the profit margin is also low. This is compounded by rising deforestation, a major threat to the sector.

Since October 2017, UN Women has trained women cooperatives in better manufacturing practices. It has also improved the equipment in shea butter production facilities so that the products meet competitive standards. We also provide financing and market access for women in the shea sector.

The next step is organic certification, which will go a long way towards increasing the value of the shea butter that the women produce. Because of the initial success of the programme, women working in the shea sector have been granted community lands. This is a significant step towards protecting the land and shea trees from the impacts of climate change and deforestation, while increasing local women's production capacity and improving their incomes and livelihoods.

Systematically addressing gender gaps in responding to climate change is one of the most effective mechanisms to build the climate resilience of households, communities and nations, and to ensure that no one is left behind. Encouragingly, the growing recognition of the disproportionate impact of climate change on women and girls has been matched in recent years by the rising awareness of both their roles as change agents and the tremendous value of gender equality and women's empowerment for producing social, economic and climate resilience benefits.

This is reflected in the 2030 Agenda for Sustainable Development and the Paris Agreement, adopted at COP21 in December 2015 under the UNFCCC. It is up to all of us to fully implement these agreements, with women taking leading roles, and to ensure that gender equality plays a central role in any climate action. ●

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Decarbonising supply chains

It is relatively straightforward for a company to cut its own emissions. But to achieve the 1.5°C target, firms will have to look at their whole value chain

By **Sally Uren**, Chief Executive, Forum for the Future

At the beginning of 2018, environmental disclosure experts CDP reported that the number of organisations requesting supply-chain data had gone up by more than 15 per cent in just one year. In total, 115 organisations – with a combined annual spend of more than $3.3 trillion – are now requesting data from over 11,500 suppliers. It's a trend that will likely continue.

Why? Because in most sectors, direct carbon emissions from an organisation's operations are dwarfed by carbon emissions relating to the production, processing and transportation of products and services in its supply chain. These so-called scope 3 emissions – which also include upstream emissions – are on average four times higher than a company's direct emissions, and up to seven times higher for retailers and consumer-facing businesses.

At the same time, the science surrounding climate change has never been starker. Readers do not need reminding that in October 2018, the Intergovernmental Panel on Climate Change released a special report calling for "rapid, far-reaching and

◀ A steel plant in Quzhou, China. The importance of scope 3 emissions is accentuated by the trend among richer countries to 'outsource' high-emission manufacturing to developing countries

unprecedented changes" to give us any hope of limiting global warming to below 1.5°C and avoiding long-lasting or irreversible damage. Just half a degree warmer, and the risks of severe floods, droughts and extreme heat will worsen significantly, while hundreds of millions of people will face living in climate-related poverty.

Taking urgent action to combat climate change and its impacts is one of the Sustainable Development Goals agreed by world leaders in 2015: Goal 13. But, based on current measures, we are heading for a 3°C rise and the very real threat of runaway climate change by the end of the century. If ever there was a time for action, it's now.

Understanding, managing and, ultimately, significantly reducing scope 3 emissions has never been more important. The Science-Based Targets initiative – a UN-business-civil society collaboration that helps businesses develop and approve carbon targets – requires companies to set scope 3 targets if these emissions account for 40 per cent or more of the total, which they often do.

The case for action

If climate science, customer pressure, or simply the fact that this is the right thing to do for future generations are not sufficiently compelling arguments for a company to take action, then the case for business continuity just might be. Much of the climate-change risk to a business is linked directly to the impact that climate change will have downstream on its supply chain – and these impacts are being exacerbated by scope 3 emissions. These are emissions that a business might not directly control, but very definitely has influence over.

The imperative to understand scope 3 supply-chain carbon emissions is therefore clear. So, how does a business go about tackling these emissions, which in some supply chains span multiple tiers?

The good news is that there is an abundance of guidance available for businesses from a wide range of sources. These include The Climate Group, Carbon Trust and CDP, as well as the World Resources Institute, which co-authored the Greenhouse Gas Protocol's *Corporate Value Chain (Scope 3) Accounting and Reporting Standard*.

Some sustainable business leaders provide useful case studies, too, having been busy measuring and managing their supply chain emissions for over a decade – in some cases longer. Both BT and Dell, for example, are using CDP data to help meet ambitious emissions targets. BT is aiming to cut supply-chain emissions by 29 per cent by 2030, while 84 per cent of Dell's direct suppliers (against a target of 95 per cent by 2020) now have greenhouse gas (GHG) emissions reduction targets and publicly report their emissions inventory.

In essence, there are four steps any business should follow:

- Initial analysis and engagement – building a supply-chain map, highlighting areas of high volume and high spend.
- Creating a carbon footprint – identifying key businesses in the supply chain, collecting emissions data.
- Identifying and prioritising opportunities for carbon reduction, focusing on high-emission sources.
- Setting targets and implementation.

When it comes to setting targets, Forum for the Future's strong advice to our partners is to adopt net positive or restorative targets. With only three years left of emissions at current levels if we want a 66 per cent chance of remaining below 1.5°C, the science calls for companies to commit to immediate and complete decarbonisation, including across their full value chain. This means redefining the purpose and intent of a corporate carbon target – with the balance between 'what's achievable?' and 'what's required?' swinging heavily towards the latter. We might even see companies set deliberately 'impossible' targets as a call to arms (with the very 'impossibility' of the target being used to drive broader change).

Traditionally, companies have looked to offset some of their direct emissions by purchasing carbon credits in external projects, and for many organisations this can be a credible way to deal with difficult-to-reduce emissions. But as companies increasingly think in terms of the full corporate value chain, an increasing number are looking to 'inset' their direct emissions by developing their own carbon offset projects within their direct supply chain.

As well as reducing emissions, such projects can also build climate resilience within a company's supply chain and help restore vital ecosystems on which the suppliers depend.

Coffee firm Nespresso, for example, has committed to planting 10 million trees among its suppliers' farms and surrounding ecosystems by 2020. Hotel group Accor has invested in several water-saving and agriculture projects affecting its own supply chains to reflect the company's huge reliance on water and food.

Beyond target-setting and off/insetting, there is a plethora of other practical ways for businesses to help cut carbon across their supply chains. These range from increasing recycling to switching to renewable energy, or from reducing the weight of packaging to swapping transport modes from air to ship.

The sky's the limit when it comes to creative and imaginative ways to encourage suppliers to act. In the case of Walmart, for example, it is the sheer audacious scale of its Project Gigaton that has garnered so much attention. Through the initiative, the US retail giant is aiming to avoid one billion metric tons of GHGs from its global value chain by 2030. Since starting last year, the project has already seen hundreds of Walmart suppliers commit to reducing emissions.

Finally, working with suppliers to reduce carbon emissions is not only good news for the planet and bottom line. Working in partnership with suppliers can also build trust and relationships, bring greater transparency to supply-chain activities, and boost innovation.

Tackling climate change is too big a challenge for one organisation to fix alone. Radical carbon reduction throughout supply chains is an absolute necessity: all businesses need to work proactively with key suppliers to cut scope 3 emissions. The guidance is plentiful, and the benefits are well documented. Start now. ●

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Finance: once more, with feeling

2018 may go down as the year in which the world finally woke up to climate change. But will it also be when finance really started to become part of the solution?

By **Raj Thamotheram**, Founder & Chair, Preventable Surprises

In September 2018, UN Secretary-General António Guterres called climate change an "existential threat" and spoke explicitly about the need for an emergency response. The following month, the Intergovernmental Panel on Climate Change (IPCC) cautioned that we have just 12 years to get on track to limit global temperature rise to 1.5°C above pre-industrial levels. So far, so normal: despite the unprecedented nature of their warnings, we have heard – and ignored – urgent calls for action before.

But this year we have finally seen growing awareness of just how conservative the IPCC process actually is. We have also seen official acceptance of the much wider nature of the climate challenge, which goes well beyond carbon and even greenhouse gas emissions. And the Bank of England will, according to the *FT*, "put banks and insurers on notice to vastly improve their planning for the long-term risks of climate change, placing senior executives in the line of fire if their institutions take insufficient action." Moreover, UN officials are finally starting to take seriously the possibility that either the finance sector will drive the change we need or it won't happen.

The role of non-state actors

Until now, officials had been largely content with finance creating the best possible mood music for national government action. But, partly as a result of US President Trump's decision to withdraw from the Paris Agreement, and the seemingly unending preoccupation of EU leaders with domestic issues, the focus has now firmly moved to 'non-state actors'. So what does this mean for the finance sector and in particular for institutional investors?

First, if the focus is genuinely on making a rapid energy transition, then it is real-world decarbonisation that matters, not portfolio decarbonisation. The latter is a luxury we may not have time for and, indeed, may be a dead end. Pseudo-scientific modelling risks becoming a distraction activity since it uses data that is almost certainly, and in multiple ways, erroneous. It plugs this data into portfolio risk models from the 1950s (so-called modern portfolio theory) that manage only relative risk.

There is no evidence this will have real-world impact any time soon. There is also an uncomfortable parallel with the risk models used to assess credit derivatives ahead of the global financial crisis, where the widespread use of flawed models gave a misplaced sense of confidence.

◀ **The #BankExit Rally in Los Angeles against Wells Fargo and Chase Bank for funding the Dakota Access Pipeline. The investment community will need to make a huge cultural leap to move from a position of detached moral judgement to becoming forceful stewards for the public good**

Second, we need a big switch in investor focus to forceful stewardship. Today, most investors think about investing sustainably primarily as a question of integration. But investors should evaluate climate strategies on one criterion: will it shift intra-firm capital allocation at the really problematic companies and sectors, and will it do so in time?

There are strong grounds for concluding that existing strategies (e.g. integration, divestment, portfolio decarbonisation, green bonds and constructive engagement) are wholly inadequate with this criterion in mind.

What this means in practice is that investors should require lower than 2°C or net-zero (by 2050 latest) transition plans, starting with high-impact (supply and demand) sectors. Industrial-scale resolutions are the only practical way to deliver this investor signal given the time available and investors' stewardship resources.

This approach is very different from the case-by-case engagement approach used today. Not even the biggest environmental, social and governance (ESG) teams could cover the number of companies that need attention, particularly those managers who have assets under management bigger than many developed-world country GDPs.

Such a systemic approach also addresses any risk of first-mover disadvantage. This is often given by both companies and investors as a case for non-action – witness the 2018 Shell AGM debate when many investors recoiled over a resolution which simply asked the company to align with the Paris Agreement.

This collaborative beta stewardship strategy should be done in addition to anything else the investor wants to do on climate, such as to make money from climate change (for example, through green funds), manage sector risk (for example, through portfolio decarbonisation) or send political signals (for example, through divestment).

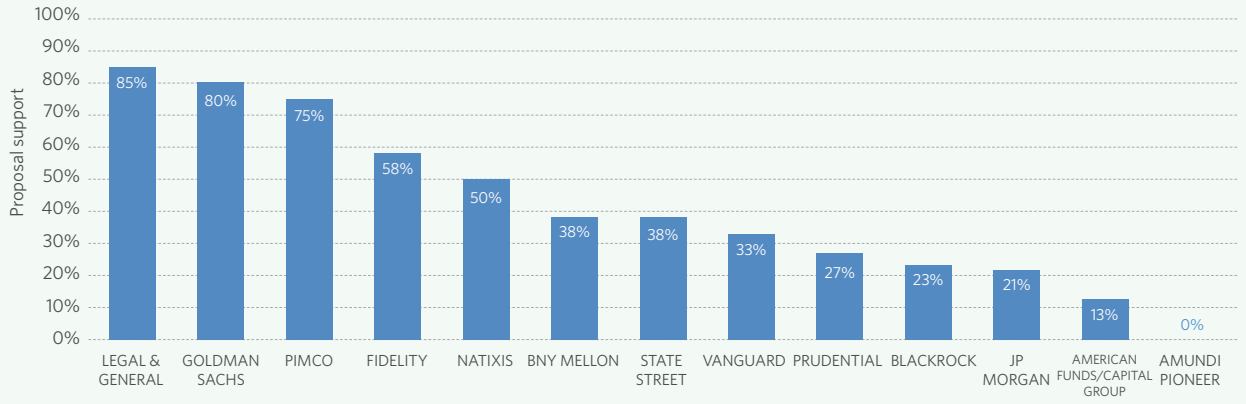
The time for virtue signalling has passed. This includes projects like the Montreal Pledge or casual signing of letters to governments, which are simply 'wish lists' that investors know will not happen

The time for virtue signalling has passed. This includes projects like the Montreal Pledge or casual signing of letters to governments, which are simply 'wish lists' that investors know will not happen, not least because they have no intention of doing the hard lobbying to make them happen. The UN and non-governmental organisations should stop rewarding such 'predatory delay' strategies since it does not convince hard-nosed corporate executives.

Climate Action 100+, a five-year investor-led initiative to engage key emitters, is well placed to coordinate the kind of forceful stewardship described above, provided that CEOs take a hands-on role in the way that happens at the World Business Council for Sustainable Development or the Business Roundtable.

Third, the focus on carbon is almost certainly not enough. This is clearest with regard to deforestation, which many leading scientists believe is just as important to stop as the use of fossil fuels. But the wider ecological crisis – for example, biodiversity loss – cannot simply be put down to climate change. That kind of climate fundamentalism

Asset manager support for shareholder proposals on climate change



The company universe includes the S&P 500 companies that are in the GICS sector 'Energy' or 'Utilities', not including the following sub-sectors: 'Oil & Gas Equipment & Services', 'Water Utilities', and 'Oil & Gas Drilling'. The asset manager universe is the 13 global asset managers that report mutual fund votes and had over $1 trillion in assets under management as of calendar year-end 2017

Source: Fund Votes Research, now part of Morningstar

is not healthy. And, even more broadly, we are very unlikely to get a grip even on climate change without parallel action to address major social issues, such as income inequality.

Investors should engage with these critical 'market wellbeing' issues of our time, as well as on the factors that underpin our lack of progress. These include gender balance and other corporate groupthink, the corporate capture of politics, and bribery and corruption – whether illegal or legalised, as is the case in the US, where "dark money" has bought political control, as Jane Mayer has convincingly documented.

Internal transformation

The importance of these wider agenda items is well described by Charles Eisenstein in his recent book *Climate: A New Story*. But even if you don't go as far as he does, it is clear that – tactically – this broader agenda is critical even for climate-focused investors. Again, the best thing investors can do is to be assertive stewards on these issues as well.

To deliver on this transformative agenda, investors need to set themselves on a path of internal transformation. In the same way that the gender challenge will not be addressed by focusing just on women, so responsible investing needs to be central to the people-management strategy for traditional analysts/portfolio managers.

How these mainstream staff are recruited, promoted and rewarded – in other words, how performance metrics are adapted to go beyond simply beating a cap-weighted benchmark – is key. And to give this process some teeth, it is important that irresponsible values and behaviour trigger negative consequences, including, if serious, dismissal. This culture change should, of course, start with senior management teams and boards of directors.

In parallel, responsible investment teams need to be endowed with appropriate status. The head of ESG should be a member of the senior executive and all the front-line ESG staff should be financially literate, as well as having strong values, in particular around stewardship. Technical ESG analytical skills are important but not enough. And there should be an informed board-level sponsor to provide air cover if needed.

Investors should use ESG performance reporting to the board, all staff and clients/investment consultants to drive continuous improvement and novel alliances. Today, managers often say, "you are the only one to raise this" when asked for something by a client. Rather, they should help concerned clients to collaborate with internal change agents to create more effective alliances for change.

Investors also need to work with their professional bodies – for example, the UN-supported Principles for Responsible Investment – to ensure it is easy to compare managers and so identify leaders/laggards/mid-range movers within the investment community. This will drive progress.

Without this focus on internal transformation, it is highly unlikely that fund managers will rise above their conflicts of interests and lack of skills to do what we all need them to do – urgently.

As Martin Wolf notes in his hard-hitting comment ("Inaction over climate change is shameful"): "The natural tendencies are either to do nothing, while insisting there is no problem, or to agree there is a problem, while merely pretending to act. It is not clear which form of obfuscation is worse."

The good news is that investors have made a policy decision to ask for transition plans from the energy sector and the 2019 AGM season will be a good test of this new commitment. ●

Investing for a better world

Charles Montanaro, Chairman of asset manager Montanaro, explains how climate change poses a global threat that requires investors to be more engaged and proactive

Amid the permafrost of Siberia's Yamal Peninsula, a group of reindeer herders called the Nenet strive to make a living. Their way of life is in danger. Climate change threatens centuries-old migration patterns. Herds arrive too late or too early to pasture. Communities dependent on reindeer crumble. As I learned, climate change kills. The same is true in warmer climates. The Korowai of West Papua told me: "dimone letel ul laniam hakko bamolo" ("the weather is all mixed up"). It's scary when well-trodden jungle paths unexpectedly turn into swollen rivers.

By day I am an investor in the City of London. But I am an anthropologist by training. Each year, I spend time with remote indigenous tribes, seeing with my own eyes the destructive force of climate change. Something needs to be done. Can investors help?

The world is facing major challenges and the UN SDGs are a call to action. The investment community has a role to play in transforming our world. Research suggests that, for the goals to be realised, some $6 trillion must be funded by the private sector each year.

At Montanaro – the asset manager I founded in 1991 – we invest in smaller companies whose products or services support the aims of the UN goals.

Even though they may not be household names, their reach is large: many have global operations, employ thousands of people, and sell their products and services to many more.

One such company makes actuators, small devices which help businesses to run their buildings with greater energy efficiency. Another produces enzymes used to enhance crop yield, helping to feed growing populations. One entrepreneur is working hard to power homes with financially viable renewable energy solutions.

> Investors need to lift their line of sight from the short-termism of quarterly earnings

A family of Nenet reindeer herders in Yamal Peninsula, Siberia, whose way of life is threatened by climate change. Charles Montanaro pictured second from right

Driving meaningful change

But creating a better world requires more than simply owning the shares of these companies. A change in investor and corporate behaviour is needed. Investors need to lift their line of sight from the short-termism of quarterly earnings and broaden their investment horizons. The UN SDGs must be realised by 2030 and to support the goals we must invest with this timeframe in mind.

As long-term, proactive investors, we can help to drive meaningful change in the way businesses operate. Through shareholder engagement, we challenge and support companies as they invest for the future. This takes time. A company that we own in the US is developing new techniques for water and air purification for use in developing markets. We will support them on this journey.

We can't do this on our own. Our recently launched Better World Fund is £120 million in size, a credible amount for a new fund, but a drop in the ocean compared to the $6 trillion needed each year. To truly make a difference, we will need to win the further support of asset owners, such as pension funds, family offices, charities and other savers.

We are excited about this challenge. As the UN Secretary-General said upon taking office: "we live in a world where problems became global and there is no way they can be solved on a country by country basis." We all have a part to play. ■

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UNA-UK thanks Montanaro for its generous support for this publication

Accelerating investment

A gap between needed and actual private investment in climate-friendly projects remains stubbornly wide. What can governments do to get more capital flowing?

By **Rory Sullivan**, Independent Adviser: Responsible Investment and Corporate Responsibility

The most recent analysis from the Climate Policy Initiative suggests that global climate finance flows in 2016 were $383 billion – two thirds of this was provided by the private sector. While $383 billion is an impressive number, it is well short of what is needed. The UN Framework Convention on Climate Change estimates that at least $1.5 trillion a year will be needed between 2017 and 2030 to meet the Paris Agreement goal of keeping average global temperature rise well below 2°C – and as close as possible to 1.5°C.

The fact that billions of dollars of capital is now flowing suggests that the most important policy question is no longer how to enable climate finance to flow. Rather, it is how might these capital flows – in particular from the private sector, the likely key engine of growth – be accelerated and scaled up? Our experiences to date suggest we need to focus on the financial characteristics of the investments themselves, on domestic climate change policy, and on climate finance policy.

The investment case

Huge amounts of private capital have been invested in solar and wind energy, industrial and domestic energy efficiency, and low-carbon technologies, in particular in developed countries. These are all areas where there is a clear financial case for investment.

There has, however, been much less private-sector investment in areas such as REDD+ (reducing emissions from deforestation and forest degradation) and climate change adaptation, and in the less developed countries. This is, primarily, a function of the basic financial characteristics of these investments. In the absence of financial support, such investments may be unattractive to a private-sector investor on a formal financial risk–return basis.

Investment is also hampered by the perception that these areas and these countries are riskier than others. This is particularly the case with newer technologies and in countries where there has been relatively little low-carbon investment.

Ultimately, these concerns can only be addressed through the relatively wide deployment of the technology, enabling its operational and financial performance to be tested under a range of operating conditions and in a range of operating environments. Wide deployment also drives unit costs down, enabling technical improvements and, at the project level, lower discount rates (as the technology is progressively seen as 'less risky').

Climate policy

Nearly 190 countries have submitted nationally determined contributions (NDCs) towards realising the Paris Agreement, committing themselves to meeting ambitious goals in areas such as renewable energy, energy efficiency and sustainable land management. Many governments have started to implement their NDC commitments by adopting carbon pricing and other market support schemes, setting energy-efficiency and other performance standards, and removing fossil-fuel subsidies. Clearly there is much more to be done – but the direction of travel is clear.

Governments need to be aware that investors often identify policy risk as the major risk to low-carbon investment. This is because many low-carbon investments (for example, more innovative forms of renewable energy, or adaptation) require some form of explicit policy support, often over extended periods of time. Investors are concerned that election cycles and the inevitable shifting of government priorities mean that policy support cannot be guaranteed over the financial life of their investments. Unfortunately, investors have an asymmetric view of public policy-related risks. They take a long time to recognise and reward governments that do a good job in this area, but are quick to criticise and to slow or stop their investment when they perceive governments as taking action that damages their interests.

Climate finance policy

Domestic private-sector investors and finance institutions, in particular in emerging markets, often lack the capacity and expertise to analyse and assess the risks and opportunities associated with investments in areas such as renewable energy and energy efficiency. These gaps can be addressed, at least in part, through focused technical assistance and capacity-building, both on deal origination and on the technical assessment of climate change-related mitigation and adaptation opportunities.

Another part of the solution is ensuring that high-quality information is available to decision-makers. This information will depend on the specific investments required but could include analysis of the financial and technical performance of previous projects, and case studies of how particular projects were developed and specific barriers overcome (for example, innovative approaches to climate-proofing existing infrastructure).

Inevitably, however, the decision on whether or not to invest will depend on the availability and the deployment of often scarce public finance. The reality is that government budgets will not, on their own, be enough to address climate

▲ An irrigation project on the Limpopo in Mozambique, designed to protect against flood and drought damage. Adaptation projects have typically struggled to attract private finance

change. Governments, therefore, need to think strategically about how they target their limited public funds to support project development to mobilise private capital. While the specific approaches and priorities will differ between countries, there are a number of general actions that governments – on their own or in partnership with others – can take:

- They can directly alter the economics of projects. For example, they could make land available for specific activities, they could ease or accelerate land use planning and other permissioning processes, and they could provide grants or other forms of direct financial support.
- They can provide concessional finance – for example, through lower interest rates.
- They can share risks – for example, through co-financing, through offering first-loss insurance, through export credit guarantees, or through currency hedging.
- They can aggregate smaller assets – examples could be domestic energy efficiency or small-scale solar – into larger pools of assets that are attractive to institutional investors for whom scale is key.
- They can support the establishment of dedicated pools of capital to support investment. For example, they could establish dedicated energy-efficiency funds or they could issue green bonds.
- They can develop standardised documentation and materials to reduce transaction costs and facilitate the bundling of investments. For example, they could support the development of standardised legal contracts; measurement, verification and reporting requirements; and energy performance contracts.

One example of a programme that combines many of these features is the World Bank's Scaling Solar programme. The programme aims to streamline project preparation and development processes, thereby helping to accelerate the development of new solar projects in particular jurisdictions. The programme brings various World Bank Group services together in a single initiative aimed at creating viable markets for solar power in each client country. The package of services includes: advice on the right size and location for solar photovoltaic power plants in a country's grid; simplified tendering processes; fully developed templates and project documentation to help speed up financing; and competitive financing, insurance support, project risk management and credit support to lower financing costs and deliver power at lower tariffs.

Replicating success

Well-designed climate change and climate finance policy can be hugely effective at attracting private-sector investment – as we see most spectacularly in the case of global deployment of renewable energy.

The challenge now is to replicate this success in other areas – energy efficiency, REDD+ or climate change adaptation – and in the less developed countries. To do this, governments will need to take action across the three pillars discussed above: the financial characteristics of the investments, climate change policy and climate finance policy. ●

People power in Indonesia

How can the public exert more pressure on governments to take action on climate change?

By **Rizal Malik**, Chief Executive Officer, WWF-Indonesia

Among the most vexing problems of our time, climate change is by far the biggest. The current ongoing rapid change to our climate has the potential to engender the end of society as we know it – yet it would be the direct result of human activity. The evidence can be seen everywhere: rising global temperatures, shrinking ice sheets in the polar caps, glacial retreat in numerous mountain ranges, rising sea levels, growing number of extreme weather events and increased ocean acidification.

The phenomenon of climate change was largely regarded as fake until the 1980s, when the first polls on the subject were carried out. Currently, the views of the public in the Eastern and Western hemispheres are not that different from each other. According to the Yale Program on Climate Change Communication, 69 per cent of Americans want to restrict carbon emissions from coal power plants. According to the European Commission, 92 per cent of Europeans see climate change as a serious problem, while 79 per cent agree that more public financial support should be given to the pursuit of clean energies – even if it means reducing or removing fuel subsidies. Meanwhile, 90 per cent of people in Europe also believe it is essential for national governments to improve energy efficiency and set targets to increase renewable energy use.

The Asia region

According to the Pew Research Center, in the Asia region, India, the Philippines and Viet Nam are the most concerned nations with at least 70 per cent of people

◀ A shaman of the Mentawai tribe in the jungle on the island of Siberut, Sumatra, Indonesia. The primary climate-change issue in Indonesia is the threat to the rainforest posed by commercial palm oil plantations; Sumatra and Borneo are the regions most at risk

agreeing that "global climate change is a severe problem". Furthermore, in 19 out of 20 Asian countries, at least 45 per cent of people want to limit carbon emissions. In Indonesia, 61 per cent of people want strict actions to be taken on climate change.

In Indonesia, the primary issue regarding climate change is the commercial palm oil plantations, especially in the regions of Borneo (known as Kalimantan in Indonesia) and Sumatra. Planting palm oil involves clearing out large areas of rainforest, reducing their rich biodiversity, resulting in the displacement and extinction of animals that live there. This includes endangered species such as the Borneo and Sumatran orangutan, Borneo pygmy elephant, Sumatran elephant, Sumatran tiger, Sumatran rhinoceros and other species that exist on the two islands.

The rainforests of Indonesia also contain carbon-rich tropical peatlands that act as carbon sinks. These are removed during deforestation, causing more greenhouse gases (GHGs) to be released into the atmosphere.

In 1970, 70 per cent of Borneo was covered with rainforest – that number has now decreased to 30 per cent and is reducing every day. The clearing of rainforests to make way for palm plantations is often done through illegal forest fires, which release up to 2.57 gigatons of carbon a year. Most recently, in 2013, the forest fires in Kalimantan represented up to 25 per cent of all global carbon emissions worldwide. Due to this, Indonesia is the fifth-largest emitter of GHGs and tops the list for forest-based emissions.

In 2015, Indonesia pledged to reduce emissions by 29 per cent and a further 12 per cent by 2030 if given $6 billion in aid. However, environmental organisations have raised doubts, citing the vague plans Indonesia currently has to target climate change. Aside from this, the government plans to build 100 coal power plants, one million hectares of palm oil and sugar plantations and increase consumption of local biofuels.

Indonesia is also set to become the largest oil importer and a net natural gas importer in the next five years, with intentions to build more car-centric infrastructure, including new highways, across the archipelago. The country is often overlooked at climate change summits, and is currently doing poorly to achieve climate goals as outlined in the Paris Agreement. Yet it could be the country that dooms the global climate, unless serious action is taken.

So what can people do? As environmental activist David Suzuki says: "In a world of more than seven billion people, each of us is a drop in the bucket. But with enough drops, we can fill any bucket."

Indonesia is often overlooked at climate change summits, and is currently doing poorly to achieve climate goals as outlined in the Paris Agreement. Yet it could be the country that dooms the global climate

First of all, it is essential for the public to be aware of climate change. Staying up to date on the recent scientific developments and remaining updated on the climate change situation is a must. Public awareness is important as it connects the public to decision-makers and those who are directly impacted by climate change. To this end, Article 6 of the UN Framework Convention on Climate Change prescribes the promotion of public awareness on climate change.

Changes in daily behaviours can also combat climate change. The use of renewable energy or low-polluting energy sources is a great first step. With decreased costs of solar panels and the development of electric cars, the process of switching from fossil fuels to renewable energy or low-polluting energy vehicles has become easier and more cost-effective.

Countries with medium-sized economies such as Thailand and Bangladesh have shown that mass installation of solar panels is feasible, with Bangladesh installing rooftop solar systems on 3.5 million homes already.

Other energy habits that can help reduce emissions include 'greening' our commute – for example, using public transport, riding a bike, or car sharing. All these activities lower net emissions as the average emissions per person decrease. These are the activities that the Earth Hour campaign is advocating, especially in Indonesia.

Since it was initiated by WWF in collaboration with the Jakarta Provincial Government 10 years ago, Earth Hour has become one of the largest public movements in Indonesia promoting environmental awareness for urban populations. The Earth Hour communities – now in more than 30 cities across Indonesia – are tirelessly campaigning to get people to use public transport, save energy, choose energy-efficient electronics, reduce waste, and become 'smart' consumers. They support local municipal governments to develop new sustainability policies and to announce their commitments or pledges towards sustainable cities during Earth Hour celebrations. They also run an education programme for children.

Progress by city governments has been positive. Jakarta, Kota Bandung and Kota Bogor in West Java, Kota Balikpapan in East Kalimantan, and Kota Surabaya, Sidoarjo and Malang in East Java have started implementing environmental principles for waste management, developing public transport facilities and utilising renewable energy for street lighting. All government buildings in these cities also implement 'green' office policies.

Climate change is a problem that we need to tackle on a united front. Politicians, in theory, act on the will of the people. Public opinion, therefore, is critical in dictating public and foreign policy. Together, individual actions can lead to a sustainable future for generations to come. ●

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A 'Moore's Law' for decarbonisation?

We need to halve CO_2 emissions every decade between now and mid-century. Can we do it?

By **Nebojsa Nakicenovic**, Deputy Director General, International Institute for Applied Systems Analysis, Austria; and **Sebastian Busch**, Research Scholar, Transitions to New Technologies Program, International Institute for Applied Systems Analysis, Austria

Climate change is an enormous challenge facing humanity. Emissions of greenhouse gases (GHGs), in particular of carbon dioxide (CO_2), are the main sources of human interference in the climate system. During the past half century, the calls for radically reducing GHG emissions led to significant international agreements, culminating in the 1997 Kyoto Protocol. But global emissions continued to increase, and we recently passed a number of tipping points.

Global CO_2 emissions now exceed 40 billion tons per year. Since the beginning of the industrial revolution, cumulative emissions have increased to more than 2,000 billion tons. Meanwhile, global mean surface temperature is more than 1°C warmer than pre-industrial levels.

In 2015, nearly two decades after Kyoto, the Paris Agreement saw world leaders adopt the ambitious and aspirational goal to stabilise climate change to below 2°C above pre-industrial levels – and if possible to below 1.5°C. The science reflected in the five assessments of the Intergovernmental Panel on Climate Change (IPCC) during the past 30 years is clear: to achieve a two-thirds probability of remaining below the 2°C threshold, cumulative net emissions of CO_2 from 2012 onwards must not exceed much more than 1,000 billion tons of CO_2.

The recent IPCC *Special Report on Global Warming of 1.5°C* indicates a slightly higher budget of up to 1,300 billion tons of CO_2 to achieve the same stabilisation level of 2°C, which would give a bit more flexibility but does not change urgency or any implications.

◀ **Volunteers planting pine saplings after a forest fire in Pinhal de Leiria, Portugal. Afforestation is one of the few measures currently available to generate net-negative emissions**

Given that emissions are increasing, the world is, unfortunately, not on the path to achieve stabilisation at 2°C. Rather, we are heading towards more than double this level of global warming

The need for immediate action

Given that emissions are increasing, the world is, unfortunately, not on the path to achieve stabilisation at 2°C. Rather, we are heading towards more than double this level of global warming. This is comparable to the global temperature change from the Earth's glacial to interglacial periods, which occurred on a geological scale of some 120,000 years. If current trends continue, the world is poised to achieve the same temperature change in a mere 200 years.

The last 10,000 years – known as the Holocene – have been characterised by very subdued changes in global temperatures, allowing humanity to settle down, develop agriculture and establish the first great civilisations. The current age has been characterised as the Anthropocene, a period during which one single species has acquired the capacity to change the climate and earth systems.

Such catastrophic rates of climate change require concentrated and immediate action. Emissions need to start declining immediately and come down to net zero by mid-century, if we are not to exceed our remaining emissions budget.

CO_2 emissions from energy and all other sectors, specifically including land use, must peak and exponentially decline. Today, about half of global emissions remain in the atmosphere and the other half are removed by natural sinks, mostly into the deep ocean. These earth-system services must be maintained and strengthened.

Falling short on these goals means that we may need to achieve net-negative emissions in the future to offset the level of cumulative emissions. One possibility is afforestation, establishing forests where there were none previously. Another is bio-energy with carbon capture and storage, or BECSS. This includes many components that already exist at commercial scales, although the technology is yet to be deployed. Recently, there have been many

calls for direct carbon capture from the atmosphere, a technology that exists at the pilot level, but needs commercialisation and to be scaled up.

Moore's Law

A metaphor for what needs to be done is Moore's Law, which states that the number of transistors on a chip will double every 2.5 years. This exponential progress is clearly not automatic, but is rather the result of strategies, innovation and vigorous plans and investments of the semiconductor industry.

By analogy, determined efforts to mitigate climate change also require strategies and roadmaps, as deep emissions reductions affect all spheres of human activities.

Last year a number of us proposed the 'carbon law' (*A roadmap for rapid decarbonization*, Rockström et al. 2017). This specifies that global CO_2 emissions must halve every decade, approaching zero by mid-century. The carbon law implies a transformational change of most human activities, including behaviour and lifestyles. It would apply to all settlements: from villages to mega cities, in all regions and nations, and across all sectors, from industry and energy to land use. In other words, achieving the 'Moore's Law of decarbonisation' is a Herculean challenge. It requires the emergence of new values, norms and institutions. Science, technology and innovation are essential for decarbonisation and sustainable development.

A critical obstacle is that decarbonisation, as an essential component of sustainable development, is currently not a self-organising property of market-based economic systems. The 'invisible hand' allocates only those scarce resources that are included in price setting. In practice, this renders many essential dimensions of decarbonisation and sustainable development exogenous, resulting in development that is rarely socially inclusive and environmentally sustainable. What we need is a dual strategy that pushes renewables and other zero-emissions technologies while at the same time phasing out fossil fuels from the market.

The carbon roadmap

Transformative change can only come about through the formulation of roadmaps and regulatory mechanisms to complement and reform essential markets. These range from norms and standards to taxes for rapid decarbonisation. Meanwhile roadmaps – planning instruments that link shorter-term targets to longer-term goals – can help to align actors and organisations to instigate technological and institutional breakthroughs to meet a collective challenge.

All told, the transformations required for economies to stay on a carbon-law trajectory encompass values, norms, innovation, institutions, infrastructures and investment. An explicit carbon roadmap for halving anthropogenic emissions every decade could help promote disruptive, nonlinear technological and institutional advances toward a zero-emissions world.

An explicit carbon roadmap for halving anthropogenic emissions every decade could help promote disruptive, nonlinear technological and institutional advances toward a zero-emissions world

If designed with decadal targets and incentives, it could provide key elements for local, national and international climate strategies.

The world is now at a crossroads: one path is transformation towards a sustainable future, the other is business as usual. The latter might appear the easier road to take, but it will lead to increasing inequalities, environmental degradation and transgression of planetary boundaries. Instead, we must find a way to put the carbon law into practice.

To fully turn the story around and deploy all possible synergies, the carbon roadmap needs to be an integral part of the Sustainable Development Goals.

A new report by The World in 2050 initiative shows that six key transformations are essential and can enable the world to meet the Global Goals. These transformations encompass all the major drivers of societal change, including human capacity, consumption and production, decarbonisation and the digital revolution. They imply deep structural changes; profound reforms of institutions; shifting mental maps and norms; changing patterns of human behaviour; widespread awareness-raising and mobilisation; the adoption of a complex, adaptive-systems approach to sustainability issues; and unprecedented problem-solving.

Holistic approach

As transformative change is needed, countries around the world require transformative governance. In view of the complexity and breadth of the changes occurring, and those to be expected, it is essential that world begins an effort to move beyond the sectoral and fragmented approach that much sustainability research has followed to date.

We should not just investigate the role of water, food or energy, or even the water-food-energy nexus. Rather, we should design an approach that truly integrates all possible domains affected, focuses on tradeoffs and co-benefits, and generally takes a holistic perspective that is at the core of the 2030 Agenda.

Another synergetic approach of the 2030 Agenda strives to harness science, technology, and innovation to accelerate progress. This holistic approach implies that the full complexity of the dynamics involved in each domain of social, social-environmental and social-environmental-technological interaction – from the basic values and world view of individual societies and cultures, to their ways of interacting, their institutions, their governance, and so on – will play out and impact on every aspect of present and future societies. ●

Realising green growth

Countries are progressing too slowly on green growth. Economic and environmental policy priorities must be more closely aligned

By **Nathalie Girouard, Ivan Haščič, Mauro Migotto** and **Miguel Cárdenas Rodríguez**, OECD Environment Directorate

'Greening the economy' is about fostering growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our wellbeing relies. Our ability to sustain economic and social progress in the long run depends on our capacity to reduce dependence on natural capital as a source of growth, abate pollution, enhance the quality of physical and human capital and reinforce our institutions.

The Organisation for Economic Co-operation and Development's (OECD's) approach to monitoring green growth is centred on production and consumption. It describes the interactions between the economy, the natural asset base and policy actions. Drawing on the OECD Green Growth Indicators framework, this article focuses on some of the economic opportunities – and challenges – of green growth in the domains of innovation, financial markets, and changing production and consumption patterns.

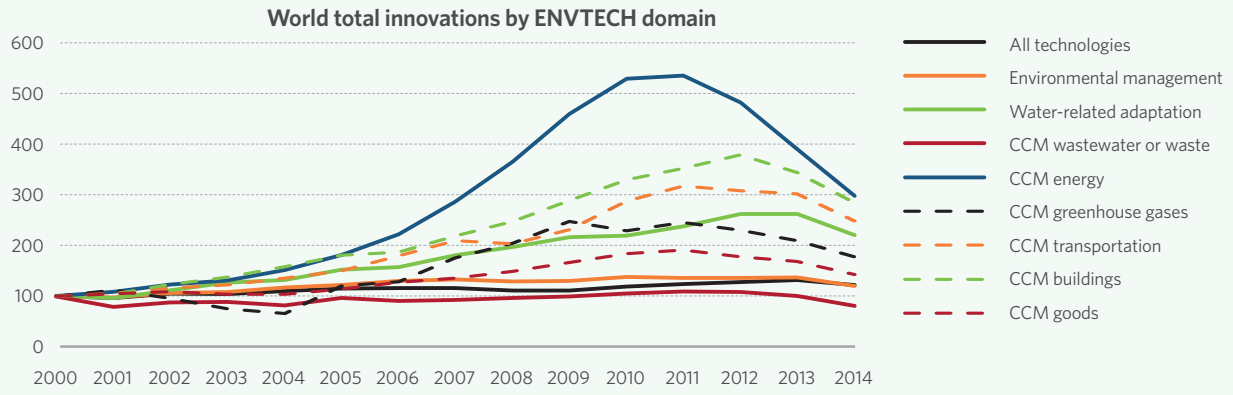
Shifting the direction of innovation

Green growth can generate economic opportunities through expanding markets for green technologies, products and services, both domestically and abroad.

▲ **The interior of Bloomberg's HQ in London, rated as the world's most sustainable office building. Innovation in climate-change related building technologies more than tripled in the decade to 2010 but has since tailed off**

Figure 1: Following a rapid increase, development of environment-related technologies is slowing

World total, index 2000 = 100. CCM = climate change mitigation



Source: OECD (2017), 'Green growth indicators', Environment Statistics (database)

Innovation is a key driver. New technologies can help achieve environmental objectives cost efficiently, and lead to new business opportunities and markets. It is widely acknowledged that far-reaching innovation will be needed to address climate change and other environmental challenges, and to accelerate the transition to green growth.

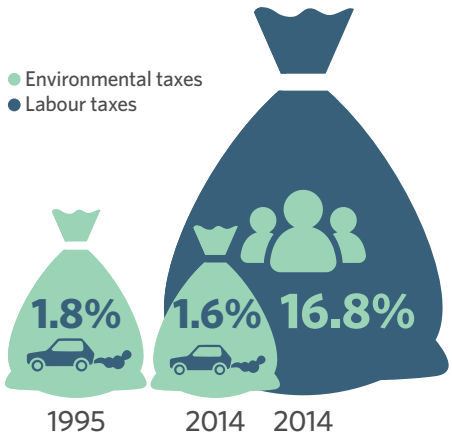
Yet, progress on innovation has been mixed. Total spending on research and development (public and private) has increased in most OECD countries. Government budgets for R&D have also increased in many countries since 2000. However, the share dedicated to environment and energy objectives has remained stagnant.

Between 2000 and 2010, innovation in environment-related technologies (measured using patent applications) increased faster than innovation across all technologies. Innovation in climate change technologies related to buildings, transport and energy in particular more than tripled. However, more recently, this activity has slowed across all environmental domains (Figure 1). This might be due to changing energy prices as well as the persistent uncertainty over the direction and ambition of environmental and climate policies at the domestic and global levels.

What we need is long-term incentives to direct innovation towards environmental objectives more effectively, in a way that generates the greatest net benefit to society. One example would be tracing a future path for pricing emissions or for tightening emission limits. Providing predictable market signals is important to guide long-term investment decisions – for example, in alternative energy sources. We also need to incentivise firms and consumers to take efficient abatement and mitigation action.

Policy must create a framework that encourages innovation. This could include measures to strengthen intellectual property protection, support R&D, promote innovation clusters, or invest in education and skills. Access to finance is also key, both for bringing prototypes to market and for investing in necessary infrastructure (such as charging stations for electric vehicles).

Environmental taxes versus labour taxes, % of GDP OECD



Source: OECD (2016), 'Environmental policy instruments', OECD Environment Statistics (database); OECD (2016), 'Revenue statistics', OECD Tax statistics (database)

Mobilising finance

Foreign finance – public and private – can be useful in countries lacking sufficient access to domestic finance. It can help catalyse investment for environmental projects and technologies, fulfilling both development and environmental objectives. It can also bring other benefits, such as international technology transfer.

Official development assistance (ODA), an important source of government-funded international financial flows, has been evolving. Development aid for renewable energy has now surpassed aid for non-renewables.

For governments to successfully attract foreign sources of finance they must first improve the framework conditions (such as the rule of law or availability of skilled labour). They must pursue policies that facilitate market entry and exit and do not discriminate between investors. Second, governments must strengthen the use of public financing to mobilise private finance for green growth projects. In particular, they should minimise the potential for public finance to crowd out private finance.

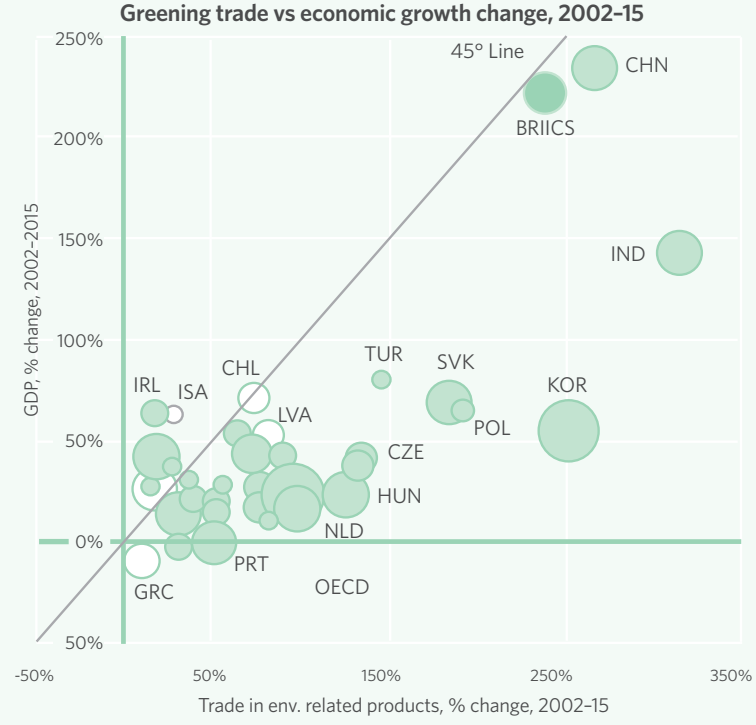
Developing markets for cleaner products

A well-managed transition to a greener economy involves a shift to cleaner products and production processes. In the European Union, the 10 most carbon-intensive industries (including electricity and energy supply, transport and some manufacturing) account for 83 per cent of all carbon dioxide (CO_2) emissions. However, on average these industries account for only 28 per cent of employment and 21 per cent of value added. The concentration of industries is even higher for some of the other pollutants (methane, fine particulates, nitrogen dioxide). In the absence of optimal policies spanning all sectors of the economy, targeting mitigation efforts on the worst polluters can reduce emissions substantially.

Encouragingly, the share of trade in environmentally related products is rising (Figure 2). This has occurred in many countries that have tightened environmental policies and regulations. It has also been accompanied by improvements in economic performance.

Reaping economic opportunities requires considerable strengthening of green taxation and incentivising innovation. This can be achieved by facilitating market entry and exit, by encouraging an efficient reallocation of labour across sectors and by 'greening' capital markets. These steps will help direct markets towards greener outcomes in a cost-efficient manner and open up new opportunities for exports and employment. Stronger international coordination can mitigate potential losses in the competitiveness of domestic industries. At current carbon prices, only very limited negative impacts on competitiveness have been found.

Figure 2: Signs that international trade might be slowly 'greening'



Note: Bubble size shows the change in the share of 'greener' trade. Green bubbles indicate an increase, white bubbles a decrease (Sauvage, 2014)

Source: OECD calculations using UN Comtrade (October 2016) and the CLEG list (Sauvage, 2014)

Pivoting taxation

Market-based environmental policy instruments play a key role in facilitating the transition towards green growth. Compared to regulatory instruments, such as emission limits or prescriptive technology standards, environmentally related taxation encourages the lowest-cost abatement across polluters.

It also provides incentives for abatement at each unit of pollution, down to zero emissions. In addition, the revenue raised can be used to support fiscal consolidation or to reduce other taxes. Shifting the overall tax burden away from labour towards environmentally harmful consumption and production patterns, while maintaining the overall level of redistribution constant, can improve economic efficiency.

But the performance of countries is mixed. Over the past 15 years, countries such as Israel, Poland, Estonia, Colombia, Costa Rica, Brazil and Turkey have shifted part of their revenue collection from labour to environmentally related activities. Some countries have introduced taxes on nuclear fuel and air travel, vehicle emissions and local air pollution.

However, overall, countries in the OECD area still raise 10 times more revenue from labour taxes than they do from environmental taxes. As a result, environmentally related taxes contributed only 5.2 per cent of all tax revenue in 2014 (equivalent to 1.6 per cent of GDP in the OECD area) and has declined in many countries since 1995.

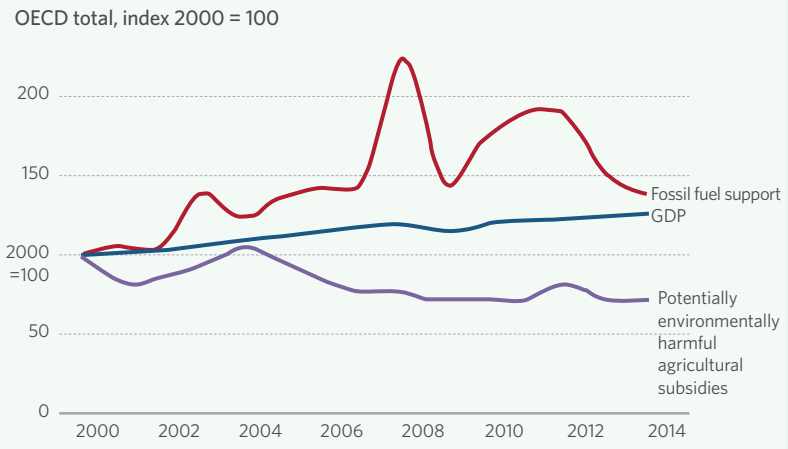
Effective carbon rates – i.e. the price of carbon emissions resulting from carbon

taxes, excise taxes on energy use, and tradable emission permits – are particularly low in sectors outside road transport. In OECD countries, the average effective rate outside the transport sector is €7.90 per tonne of CO_2. Only six per cent of priced emissions are above €30 per tonne (a conservative estimate of their cost to society) and 65 per cent of emissions are not priced at all. In some emerging economies (Brazil, Russia, India, Indonesia, China, South Africa) only two per cent are priced above €30 per tonne and 81 per cent of emissions are not priced at all.

There is wide variation in effective carbon rates across economic sectors. Road transport has comparatively higher effective carbon rates than other types of transport, manufacturing, the residential and commercial sector, and electricity production. Effective carbon rates in these sectors remain low despite their significant environmental impacts. This suggests important opportunities for countries to reform their energy tax systems and achieve environmental goals more cost efficiently.

For green tax reform to succeed, we need to address two main challenges. First, abatement should be incentivised across all sources of emissions, not just selected sectors. Second, all types of support or preferential tax rates for fossil fuels should be discontinued. This also implies that potentially regressive distributional tax impacts must be addressed, for example, to protect vulnerable households.

Figure 3: OECD countries continue to support potentially environmentally harmful activities



Source: Calculations based on OECD (2017), 'Green growth indicators', Environment Statistics (database); OECD (2016), 'Inventory of support measures for fossil fuels'; OECD (2016), 'Agricultural support estimates (Edition 2016)', OECD Agriculture Statistics (database)

diesel-powered company cars. Such environmentally harmful discrepancies should be eliminated.

Phasing out perverse subsidies

Efforts to promote renewable energy and energy efficiency are also frequently undermined by subsidies – both explicit and implicit. Countries continue to support fossil-fuel production and consumption in many ways, at a cost of more than $60 billion per year in the OECD area (Figure 3).

Another example is research, development and demonstration (RD&D). Public expenditures on energy-related RD&D increasingly target renewable energy in most OECD countries. In the Slovak Republic, Spain, Portugal, Ireland and New Zealand, over half of public-energy RD&D is now directed towards renewables. In Japan, France and Australia, this share has more than quadrupled since 2000. However, public funding for fossil-fuel RD&D keeps rising in Italy, Japan, Canada and Austria, and now accounts for over a quarter of publicly funded energy RD&D in Poland and New Zealand.

Most OECD countries and partner economies have implemented some measures to begin pricing pollution and provide incentives for efficient resource use. However, no country has yet comprehensively linked environmental and economic reform priorities. To drive green growth, governments must embed environmental challenges at the heart of economic policymaking, by linking environmental and economic reform priorities in a consistent set of objectives. Finance and economic ministries have a major role to play. ●

Governments must embed environmental challenges at the heart of economic policymaking, by linking environmental and economic reform priorities

Third, we need to address misalignments in taxation. For example, diesel causes more emissions of CO_2 and local air pollutants than an equivalent volume of petrol, meaning that its tax per litre should be higher. Yet, in most OECD countries, the excise tax rate per litre on petrol is higher than on diesel.

Some countries also provide tax rebates or other preferential tax treatment for

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The bottom line

Once investors truly understand the climate risk to their portfolios, investment should start to support climate action, not just on the basis of ethics but out of self preservation

By **Christa Clapp**, Research Director for Climate Finance, Center for International Climate Research (CICERO)

One of the striking features of the lead-up to the Paris Agreement was the active push by some leading actors from financial institutions and businesses for stronger signals on climate policy. Globally, we need to strengthen policies to avoid the most dangerous impacts of climate change. But we also need financial actors to play their role to solve the climate challenge.

Today's vast capital markets need to be redirected to low-carbon and climate-resilient infrastructure. Every dollar invested needs to be aligned with climate goals – or at least not obstruct progress towards climate goals.

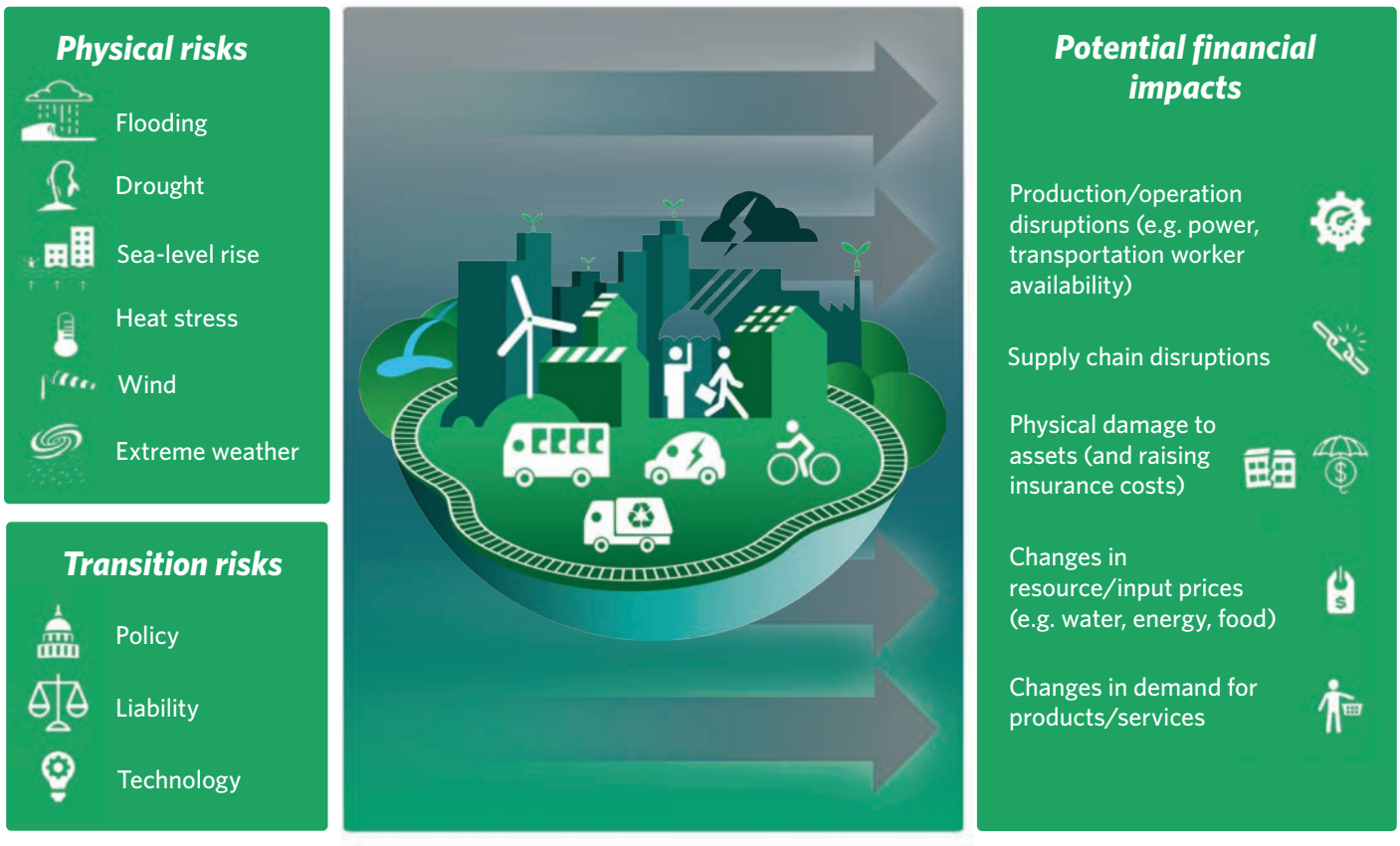
In parallel to the call to action signalled by Paris, the Financial Stability Board (FSB) – spearheaded by Bank of England Governor Mark Carney as FSB Chair – began sending a clear message to the financial sector that climate risk is financial risk. This integration of climate change into considerations of financial risk essentially turned the framing of climate change for investment decisions on its head. Previously, the argument had been around ethics and responsibility, calling on investors to contribute to a solution and consider the impacts of their investments on the climate.

The reframing by the FSB considers the potential impact of the climate – and related policy and technology changes – on financial bottom lines. This brought climate risk onto the radar of financial actors as it touched upon their primary mandate: to generate financial returns.

Defining climate risk for investors

Climate risk can be simplified into two categories:

Figure 1: Climate risk and potential financial impacts



Physical risk manifests in abrupt and chronic hazards, such as extreme weather events like hurricanes, flooding and heatwaves. Physical impacts can be felt both directly (via infrastructure damage) or indirectly (via supply chain and transportation disruptions). Physical risk can affect all sectors.

Transition risk refers to the possible changes in carbon pricing schemes or technologies. Transition risk can impact markets, resource pricing and consumer behaviour in all sectors. In the short-to-medium term, industries that supply or use fossil fuels are most likely to be at risk.

To explore transition risk, investors and corporations can use 'climate scenario stress testing' to assess how their financial assets will be affected under a range of possible future scenarios. But there are many questions as financial actors begin to implement these recommendations. What scenarios should they use? What do the scenarios mean? How can actors manage risk under different scenarios?

A risk framing of climate scenarios explores both the potential lower and upper ranges of emissions trajectories. We need to plan for a 2°C warmer world, but at the same time recognise that it is not the most likely outcome given today's policy ambition. However, key political and technological events can influence temperature increase, pushing it up above 4°C or limiting it to 2°C. Thus we should plan for a 2°C temperature rise, but also for 3°C and 4°C, as we explain in our 2018 report, *Climate Scenarios Demystified*.

To assess near-term physical risk, scenario stress testing is not helpful. Over the next 10 to 20 years, physical risks like flooding or immediate extreme events will be exacerbated regardless of the scenario due to unavoidable emissions and their effects in the atmosphere (see our 2017 report, *Shades of Climate Risk*).

For near-term physical risk, investors and companies must instead consider the probabilities of physical events occurring today and their resilience to cope with such events. By limiting current and future emissions, we can limit more and worse impacts in the second half of the century.

Risk disclosure with regional flavours

To help identify the information the financial sector needs to assess the potential climate risk faced by companies, the FSB established the Task Force on Climate-related Financial Disclosures (TCFD), led by the investor and philanthropist Michael Bloomberg, who is also UN Special Envoy on Cities and Climate Change. The TCFD recommendations, published in 2017, provide voluntary guidance to all financial institutions and companies to disclose their strategies and targets to manage their material climate risk. The recommendations include stress-testing across a range of scenarios, including 2°C.

Meanwhile there is a push to move beyond voluntary guidance into mandatory requirements on climate risk. France became the first country to pass a law (in 2015) requiring reporting on climate risk. Article 173 of the French law on Energy Transition and Green Growth requires French institutional investors to explain how they integrate environmental, social and governance (ESG) criteria into their risk management and report on physical and transitional climate risk.

Investors are increasingly referencing the SDGs as they incorporate development, climate and environment angles

This year, the European Commission launched the Action Plan on Sustainable Finance and supported measures for its implementation. The EU's vision of sustainable finance incorporates aims for low-carbon investments and considerations for climate risk on the sustainability of the financial system. The package of implementing measures includes proposals for regulations on framing definitions for sustainable and green finance, for mandatory disclosure on integration of ESG factors in risk management (similar to France's regulation) and for creating new benchmarks for low-carbon impact.

The path forward on climate risk disclosure and definitions will likely have a regional flavour. Agreement within the EU on sustainable finance definitions will not come easily, given the different energy resources across the member states. Outside of the EU, different regions and countries will consider their own priorities.

We see regional nuances already to some extent in the green bond market, one of the most recognisable financial products for climate-friendly investments. The voluntary Green Bond Principles (GBP) are a starting point for most green bond issuers in the market today. But as the market has grown, different regulatory practices and 'green' definitions have evolved.

For example, both India and Indonesia have designed local regulations that are compatible with the GBP, but with some additional, locally oriented clarifications. Countries within the Association of Southeast Asian Nations (ASEAN) developed a Green Bond Standard that explicitly excludes fossil-fuel energy generation. China requires issuers to verify projects against a catalogue of eligible green assets, which allows for clean coal projects. And the European Commission's Sustainable Finance implementation package includes specific direction to develop a green bond taxonomy of eligible projects in the EU.

Investors are also increasingly referencing the Sustainable Development Goals (SDGs), as they incorporate development, climate and environment angles. In the green bond market, we see several bonds indicating which SDGs they are targeting for impact reporting. A separate sustainability bond market is also emerging, governed by voluntary Sustainability Bond Guidelines.

A common language on green and sustainable finance can be helpful for supporting the necessary capital shift towards low-carbon and climate-resilient infrastructure. But in the push for standards and common definitions we should motivate a race to the top that allows for some inevitable regional differences in approach. Common definitions can support climate risk transparency. They should take a holistic approach to climate risk. ●

Ramping up renewables

The new IPCC Special Report on Global Warming of 1.5°C makes it starkly clear that the transition to renewables needs to accelerate

By **Adnan Z. Amin**, Director-General, International Renewable Energy Agency (IRENA)

Limiting the global temperature rise to well below 2°C this century is one of the defining challenges of our age. Two thirds of greenhouse gas emissions come from energy-related sources. This makes the transition to sustainable energy the decisive factor in tackling climate change.

Renewable energy, together with energy efficiency, form the cornerstone of the world's mitigation strategy. They represent a safe, reliable, affordable and immediately deployable pathway to a low-carbon future that can achieve over 90 per cent of the energy-related CO_2 emission reductions needed to meet climate goals. Avoiding the worst effects of global warming will require us to source at least 85 per cent of global

▲ The Burbo Bank wind farm in the Irish Sea off New Brighton, north west England. The UK has reduced its dependency on coal from 40 per cent to just over 6 per cent in the last five years and was responsible for half of Europe's expansion in offshore wind capacity in 2017

power from renewables, with a minimum of two thirds of total energy from renewable sources – wind, solar, geothermal, hydro, bioenergy and the burgeoning tidal technology – by 2050. This means that we must utilise the solutions available to stimulate systemic transformation towards a digitalised, decentralised and decarbonised energy paradigm.

In addition to mitigating climate change, such an energy transition could also deliver long-term economic and social benefits. IRENA's *Global Energy Transformation: A Roadmap to 2050* shows that it would boost global GDP by one per cent by 2050 and create millions of new jobs.

Last year alone, the renewable energy sector created half a million new jobs, reaching a total of 10.3 million. The business case for renewables has never been stronger. It is encouraging that this transformation is already underway. Most notably, there is momentum within the electricity sector. Today, renewable energy meets a quarter of global electricity demand. In 2017 the world installed 167 gigawatts (GW) of renewable energy capacity – more than the total installed electricity capacity of Brazil – and a record in new capacity terms.

Against a backdrop of falling costs across the technology spectrum, renewables are fast becoming the most cost-effective source of new power generation in much of the world. IRENA's *2017 Renewable Power Generation Costs* analysis estimates that by 2020 renewables will be cost competitive

Also in this section

with fossil fuels in most parts of the world, and in many cases will be much cheaper.

Low-cost renewables have been a key factor in recent developments. The UK, for example, has reduced its reliance on coal for power from 40 per cent in 2012 to 6.3 per cent in the period October 2017 to September 2018, as a result of its rapid renewable energy adoption. Half of Europe's offshore wind-capacity growth in 2017 was in the UK.

Furthermore, in June, the European Union increased its renewable energy targets to 32 per cent from 27 per cent by 2030, demonstrating that a cost-effective pathway to a higher share of renewables exists.

Indeed, renewables are a global trend. In 2017, China added a world record of 53 GW of solar photovoltaic capacity. Meanwhile, Morocco is turning the desert into a resource and aims to generate 510 megawatts of concentrated solar power from its new plant in Ouarzazate. Even oil and gas-exporting countries worldwide are now investing in renewables. The energy strategy of the United Arab Emirates, where IRENA is based, seeks to cut carbon dioxide emissions by 70 per cent by 2050, and to generate 44 per cent of its power from renewables. Last year, the Russian Federation conducted its largest-ever renewable energy auction, awarding contracts for 2.2 GW.

Falling costs have brought corporate actors to the table too. Companies in 75 countries actively sourced 465 terawatt hours of renewable energy in 2017, an amount close to the overall electricity demand of France. More than 200 companies reported sourcing at least half of their power needs from renewables.

Outside of the power sector, however, progress is lagging. End-use energy sectors, such as heating and cooling in buildings, and transportation, are a major source of energy-related emissions. Yet the share of renewables in these sectors remains low, with little progress in recent years. Instead, they still rely predominately on fossil fuels.

Replacing these polluting fuels with electricity, while also ensuring that this electricity is increasingly generated from renewables, is the key to reducing the carbon emissions of these end-use sectors.

Transport is a good example of such an opportunity. Electrified mobility is on the rise. In 2017, 1.2 million new electric vehicles (EVs) were sold globally, equal to around 1.5 per cent of all vehicle sales. In the last five years, EV sales have grown at an annual rate of 52 per cent. By 2050, up to one billion electric cars could be on the road.

In parallel, renewable power can provide energy for hydrogen production – an emission-free fuel, which can complement electricity and biofuels in the energy mix of the transport sector. While significant investments are required, this combination could lead to a 70 per cent fall in oil consumption for transportation, significantly reducing emissions.

Benefits outweigh costs

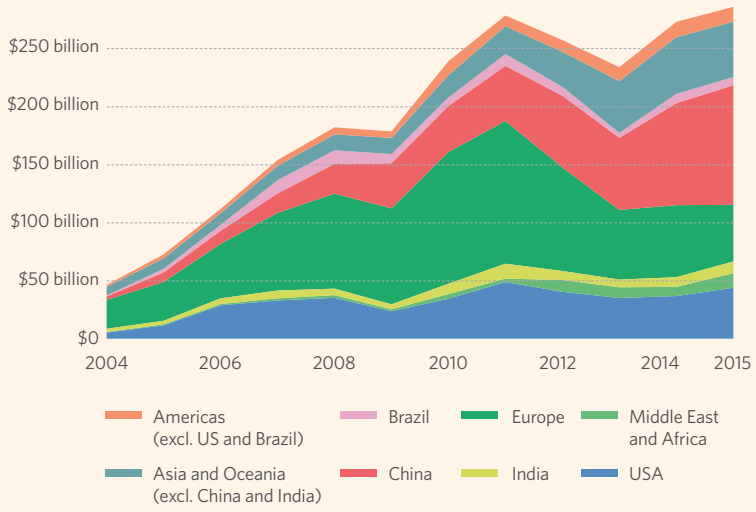
The deployment of renewable technologies can stimulate new economic activity, creating jobs, mitigating stranded assets and giving rise to cleaner, healthier environments. The benefits deriving from energy transformation significantly outweigh its costs. In economic terms, the cost savings resulting from improved human health, lower air pollution and avoided environmental damage by 2050 equal up to five times the additional investment needed to make the transition.

If we were to meet our targets by 2050 nearly 40 million people would be directly employed in renewable energy and energy efficiency. And the global economy would enjoy a $52 trillion cumulative GDP gain.

Renewables are the key to a climate-safe world. Far from having to choose between mitigating climate change and economic growth, it is clearer than ever that an opportunity exists to ramp up investment in low-carbon technologies and shift the global development paradigm from one of scarcity, inequality and competition to one of shared prosperity – in our lifetimes. If we take bold decisions now, a sustainable energy future is within reach. ●

Renewable energy investment

Investment in renewable energy technologies per year in billion US dollars by region.

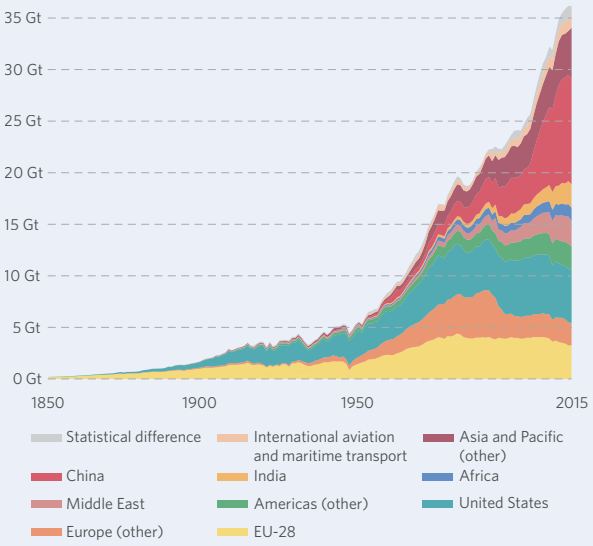


Source: International Renewable Energy Agency, 2017

GHG SOURCES

Annual CO_2 emissions by world region

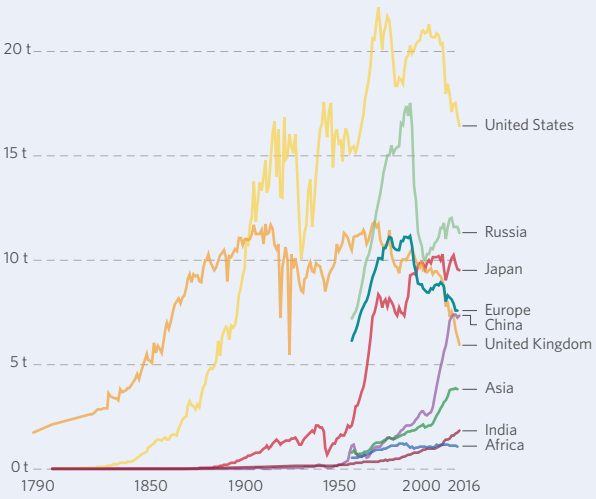
Annual carbon dioxide (CO_2) emissions measured in billion tonnes (Gt) per year



Source: Carbon Dioxide Information Analysis Center (CDIAC)

CO_2 emissions per capita

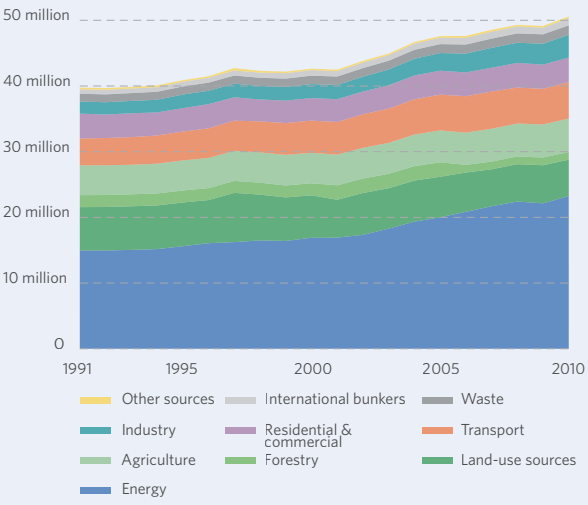
Average carbon dioxide (CO_2) emissions per capita measured in tonnes per year



Source: OWID based on Global Carbon Project; Gapminder & UN

Global GHG emissions (CO_2e) by sector

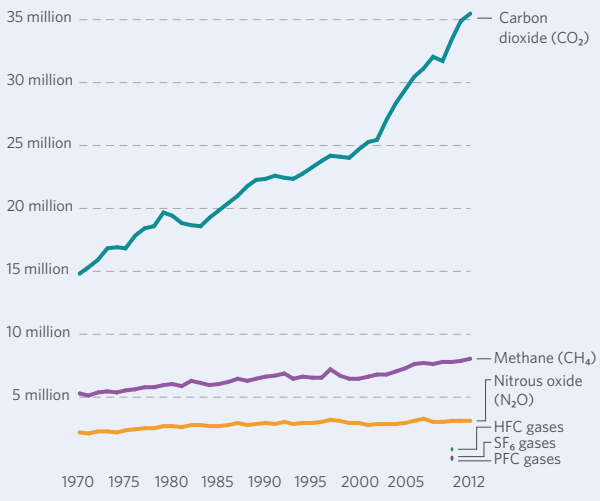
Breakdown of total global greenhouse gas emissions by sector, measured in gigagrams of carbon dioxide equivalents (CO_2e)



Source: UN Food and Agricultural Organization (FAO)

Global GHG emissions (CO_2e) by gas

Global greenhouse gas emissions by gas source, measured in thousand tonnes of carbon dioxide equivalents ($ktCO_2e$)



Source: World Bank – World Development Indicators (WDI)

A vision for zero-carbon energy

The Dubai Electricity and Water Authority (DEWA) has a clear roadmap to help combat climate change between now and 2050

Interview with HE Saeed Mohammed Al Tayer, *MD & CEO, Dubai Electricity and Water Authority (DEWA)*

The United Arab Emirates (UAE) Government is committed to confronting climate change. It is doing this through innovative and coordinated action aimed at minimising the risks to its natural environment and economic activity.

Several policies, from both the UAE Federal Government and the Dubai Government, include objectives to mitigate climate change impacts and diversify sources of energy. Dubai in particular has established ambitious clean energy goals, with DEWA playing a critical role. In accordance with the comprehensive strategic guidelines for the Emirate of Dubai, DEWA is increasing its renewable energy targets, managing energy demand, and further reducing its carbon footprint.

Responding to energy policy and regulation

The Government of Dubai has set its own ambitious strategies to help tackle climate change. These include the Dubai Carbon Abatement Strategy, with its target of reducing carbon emissions by 16 per cent by 2021. This in turn supports national strategies such as UAE Vision 2021 and the Green Economy for Sustainable Development Initiative launched by His Highness Sheikh Mohammed bin Rashid Al Maktoum, Vice President and Prime Minister of the UAE and Ruler of Dubai.

At DEWA, we are responding to growing demand by diversifying our energy sources, playing a key role in achieving the targets set out by the Dubai Clean Energy Strategy 2050. The strategy seeks to transform Dubai into a global hub of green energy, and generate 7 per cent of Dubai's total power output from clean resources by 2020, 25 per cent by 2030, and 75 per cent by 2050. Meanwhile, Dubai's Demand Side Management Strategy aims to reduce energy and water demand by 30 per cent by 2030, by strengthening the renewable energy sector to meet the objectives of the clean energy strategy.

In this way, DEWA supports the UAE's ambitions towards sustainable development, meeting continuously rising demand without diminishing natural resources or damaging the environment.

As Dubai's sole provider of power and water, DEWA recognises the impact of its operations. We acknowledge our role in realising these strategic objectives by minimising our environmental footprint, while maintaining a reliable supply of electricity and water to our customers.

DEWA also plays an integral role in helping to achieve these policy objectives. We are reducing the carbon intensity of electricity and water production,

In terms of capacity, the Mohammed bin Rashid Al Maktoum Solar Park (above) is the world's largest single-site solar park

enabling our stakeholders to reduce consumption, while also raising awareness about the impacts of climate change.

We run our power stations and desalination plants according to the highest standards of reliability, efficiency, quality and environmental safety. DEWA also owns and operates aquifers and power and water distribution networks in Dubai, ensuring the uninterrupted supply of services to our customers.

Big projects, smart innovations

As part of our efforts to tackle the challenges raised by climate change, we're working on several mega projects and innovative solutions to expand green energy use and cut emissions. These include:

Mohammed bin Rashid Al Maktoum Solar Park

The Mohammed bin Rashid Al Maktoum Solar Park is the largest single-site solar park in terms of capacity in the world. Based on the independent power producer model, by 2030 it will combine both photovoltaic (PV) and concentrated solar power technologies to achieve a total capacity of 5,000 megawatts (MW) – and cut CO_2 emissions by more than 6.5 million tons a year.

The solar park – located in Seih Al Dahal, 30 kilometres south east of Dubai – combines the efforts of both public and private sectors in solar energy. It will be home to one of the largest research and development centres in the region, and already includes a PV solar testing facility.

The park began operations in 2013, with a capacity of 13 MW generated by PV technology. The second phase began in April 2017, ahead of schedule, boosting total capacity by 200 MW.

DEWA awarded the development of the third phase to a consortium led by the Abu Dubai Future Energy Company (Masdar). The phase will be implemented in three stages, adding 200 MW of generating capacity by 2018, 300 MW by 2019 and 300 MW by 2020.

The fourth phase – a 700 MW concentrated solar power (CSP) plant – will feature a 260-metre solar tower, the tallest of its kind in the world. The project was awarded to a consortium comprising Saudi Arabia's ACWA Power and China's Silk Road Fund, along with China's Shanghai Electric as the main engineering, procurement and construction contractor. It will represent the world's lowest levelised cost of electricity of USD 7.3 cents per kilowatt hour. The plant will roll out in stages, starting from Q2 of 2021. By 2030, the solar park will generate 1,000 MW using CSP technology.

Sheikh Mohammed bin Rashid Al Maktoum (left) with DEWA's MD and CEO Saeed Mohammed Al Tayer, reviews plans for the Hatta hydroelectric power station, which will be the biggest in the Gulf. The project will add vital clean energy storage capability, as well as contributing to water security and flood control

Shams Dubai

As part of the Smart Dubai goal to make Dubai the smartest and happiest city in the world, DEWA has launched the Shams Dubai initiative to connect solar energy to buildings and households. The initiative encourages household and building owners to install PV panels to generate electricity, and connect them to DEWA's grid. Owners use the electricity they generate on site, and export any surplus to DEWA's grid, which is deducted from the customer's future bill.

Shams Dubai supports the Dubai Clean Energy Strategy 2050. It establishes a sustainable model for providing clean energy and supporting Dubai's economy, without harming the environment and natural resources.

Hydroelectric power station in Hatta

DEWA has completed engineering studies for a new 250 MW hydroelectric power station in Hatta, the first project of its kind in the Arabian Gulf. The power station will use water stored in the Hatta Dam to generate electricity. The dam can currently hold up to 1,716 million gallons, while a new upper reservoir – 300 metres above the dam level – will add a further 880 million gallons of capacity. The power station will have an expected lifespan of 80 years.

There are many benefits of hydropower. It is low cost, reliable and an efficient source of clean energy. It is also the most important means of energy storage, with estimates suggesting that hydropower represents 99 per cent of the world's operational electricity storage. Hydropower is one of the most flexible and sustainable renewable energy sources. It can be operated to provide base-load power, as well as peak-load supply through pumped storage. Other benefits include water security, flood control, drought management, irrigation and recreation.

EV Green Charger

The transport sector is the second highest contributor of greenhouse gas emissions in Dubai. We want to encourage commuters to use hybrid and electric vehicles, and to help reduce carbon emissions. To help achieve this, DEWA has successfully installed more than 100 Electric Vehicle (EV) Green Charger stations, which will be doubled by the end of this year.

At DEWA we strongly believe that the proper management of climate change risk and the promotion of measures to deal with global warming will lead to solutions to social problems, and will contribute to maintaining and increasing corporate value.

This belief is underlined by our motto: for generations to come. ■

هيئة كهرباء ومياه دبي
Dubai Electricity & Water Authority

UNA-UK thanks DEWA for its generous support for this publication

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Delivering clean energy in Asia

After three decades of rapid growth in Asia, driven by cheap fossil fuels, sustainable options are the most promising for those still without access to energy

By **Ashok Bhargava**, Director (Energy), Central and West Asia Department, Asian Development Bank

The power system in any country is one of its most complex, expensive and sophisticated set of assets. It provides electricity 'just in time' at the flick of a switch to millions of homes, offices, industrial and commercial complexes, and many other essential services. Reliable electricity is the backbone of any modern economy – and essential for the wellbeing of people.

Power systems across most developing countries in Asia grew in line with rapid economic growth over the last three decades. However, this growth was fuelled by burning cheap and abundant fossil fuels: coal and, to a lesser extent, natural gas. This has led to widespread air quality issues and large increases in carbon dioxide emissions. Considering that the power sector accounts for about a third of emissions, its critical role in addressing these issues cannot be emphasised enough.

Looking ahead, Asia is projected to double its current power system capacity by 2030. While this may be achievable, it raises serious questions about climate change and sustainability. Unless we deal with these issues properly, such rapid expansion could have serious consequences in many developing countries across the region.

So, what are the major issues?

In developing Asia, more than three quarters of electricity is generated from fossil fuels. Continuing on this path is environmentally unsustainable and is directly at odds with the Paris Agreement. Despite significant progress on renewable energy in large countries like China and India, coal and natural gas continue to be the fuels of choice in the region. Prices are kept artificially low through enormous subsidies. The economic burden of air pollution and climate change is often ignored in investment decisions.

Since 2000, there have been impressive efforts across the region, bringing electricity to 170 million previously unconnected people. However, these services are often inadequate and of poor quality, and nearly

◀ A herder family in Must, Mongolia. Their *ger*, a traditional Mongolian tent, is powered by solar panels. Small off-grid solutions are often the simplest and most practical way to address energy poverty

400 million people remain without access to electricity. The looming energy poverty in the region is a serious risk to achieving the 2030 Sustainable Development Goals (SDGs), in particular SDG 7: to ensure access to affordable, reliable, sustainable and modern energy for all. The typical response from the power utilities has been to focus all their efforts on extending the grid to unserved areas; a strategy that has not worked well. The potential of renewable energy-based, off-grid solutions have largely been neglected.

Public-sector control of power assets has created many large state-owned enterprises (SOEs) that are prone to government interference and often compelled to compromise commercial interests. This has often resulted in: a) inefficient and poorly managed SOEs with no competition; b) significant technical and commercial losses (such as metering errors and energy lost through the equipment used for transmitting electricity); and c) subsidised electricity set at a below-cost tariff, for political reasons. Combined, these factors have led to financially weak SOEs that rely on government fiscal support. In many jurisdictions, the state spends more on electricity subsidies than on education and health combined.

To keep up with rapid growth in demand, governments have often preferred accelerated capacity expansion over much-needed sector reforms. The weak financial status of SOEs, poor sector governance, inadequate regulations and frequent government interference have deterred private investment. Studies have estimated that the power sector in developing economies across the region will need about $7 trillion of investment between 2016 and 2030. Unlocking private investment will be crucial.

Hard choices ahead

Power sector leaders, experts and governments all understand the problems the power industry faces. But given the enormous challenges of extending electricity to unserved populations while meeting rapidly expanding demand, often the priority is simply to keep the lights on. Making the comprehensive reforms needed to shift to sustainable, low-carbon energy generation is often perceived as a high-risk strategy. This is due to lack of familiarity with the technology, the high capital costs it would involve and the challenges of integrating new systems with existing infrastructure. Despite this, in 2017 Asia accounted for nearly two thirds of the worldwide increase in renewable energy generating capacity. But widespread application of low-carbon technologies such as wind, solar and battery power is limited to a handful of countries in the region.

So, how can we facilitate the shift to low-carbon energy? Phasing out fossil-fuel subsidies is a good starting point. Developing Asian countries account for a third of these subsidies worldwide. Removing them will: a) level the playing field for renewable energy uptake; b) trigger electricity pricing reforms; c) stimulate investment in energy efficiency; and d) free up fiscal resources to address more pressing development needs in sectors such as education and health.

Governments, however, have often been reluctant to reform tariffs and phase out subsidies, fearing stiff opposition from beneficiaries and social unrest. This mindset needs to change. In parallel with tariff reform, we need measures to protect the poor and vulnerable, while also improving the quality of services.

The ongoing extension of networks to areas without electricity must be complemented by a decentralised system focused on renewables, designed to speed up provision of electricity to these regions. This will require looking again at the delivery mechanisms for electrification of unserved areas. New and innovative business models – such as wider partnerships with NGOs and other social and community organisations – will be needed to improve the sustainability of such efforts. Many such innovative approaches are already in progress, but we need to scale them up.

Another policy goal should be to seek more private investment. We need a concerted effort by governments to undertake comprehensive and bold reforms that can restore the financial health of the sector, limit governments' own interference in it and promote good governance with transparent policies and regulations.

In 2017, the share of private investments in renewable energy worldwide was more than 90 per cent of the total $263 billion. This clearly highlights that private investors do respond decisively when the building blocks are in place.

A sustainable path

The power sector in developing countries across Asia is at a crossroads. The sector has done reasonably well to power these countries during a challenging period of rapid growth. However, the bigger challenges of environmental sustainability, climate change responsiveness and more inclusive services to the whole population remain critical bottlenecks. These are formidable challenges that require changing mindsets, international cooperation and unwavering commitment to reform.

Nearly all countries have shared their ambition and commitments – as part of their nationally determined contributions – to adopt cleaner energy under the Paris Agreement. But there has been a sluggish start so far on translating these into significant actions. Policy gaps, conflicting priorities and the business-as-usual approach continue to stifle decisive action.

Suitable market-based policies, advanced and affordable low-carbon technologies and innovative financing solutions such as those outlined here have worked well in many jurisdictions, including within the Asia region. International financial institutions have a deep understanding of the sector's core issues. Working in partnership with climate financing mechanisms such as the Green Climate Fund, they can provide critical support for countries to get on the right trajectory for realising a more sustainable power system.

The way ahead may appear to be full of hard choices. But, considering what is at stake, doing nothing or not enough is not an option if we want to achieve the SDGs and the ambitions made in Paris. ●

Priorities for the poorest

Progress must be made, locally and internationally, to create an environment where climate action and access to energy are congruent goals in least developed countries

By **Jukka Uosukainen**, Director, Climate Technology Centre and Network (CTCN) and **Hamid Abakar Souleymane**, LDC representative to the CTCN Advisory Board

The adoption of Agenda 2030 and its Sustainable Development Goals (SDGs) marked a new level of political recognition of the important role of energy in achieving sustainable development. The pathway to reaching universal access to modern energy, however, has not been straightforward – especially for least developed countries (LDCs).

For years, the 47 LDCs have pushed for climate technology transfer to support their development priorities at the highest international forums. The UN's 2011 Istanbul Programme of Action and 2015 Addis Ababa Action Agenda both focus on developing productive capacities for LDCs and enabling global frameworks for financing development post-2015. Earlier this year, the Technology Bank for LDCs, modelled on the United Nations University, was established to strengthen the science, technology and innovation capabilities of LDCs.

In 2016, LDCs launched the Renewable Energy and Energy Efficiency Initiative for Sustainable Development. This initiative is owned and driven by LDCs to enable them to more quickly harness renewable energy potential and promote energy efficiency.

In addition to these efforts, all 47 LDCs have submitted national climate action plans to support the objectives of the Paris Agreement. For example:

- Ethiopia's Climate-Resilient Green Economy strategy aims to reach net-zero emissions and lift Ethiopia out of LDC status by 2025.
- Bhutan has committed to remain carbon neutral, which it has been since 2010.
- Tuvalu has pledged to generate all its electricity from renewables by 2025.

While these plans differ considerably across LDCs in terms of detail, ambition and technology choices, they are nonetheless a clear indication of countries' political will to transition towards low-carbon economies. But good intentions will only take you so far.

A recent study by the Technology Executive Committee of the UN Framework Convention on Climate Change (UNFCCC) suggests that while LDCs may be eager to accelerate their development across the full spectrum of the SDGs, they still face tremendous barriers to combat climate change and increase energy access. Challenges include: the quality of technology and performance; limited institutional and organisational capacity; and the struggle to attract investment capital due to low GDP growth, less mature financial markets, and poor infrastructure.

Practical steps

Without doubt, even as advances in clean technologies make low-carbon pathways economically and technically feasible, international collaboration remains vital to enable LDCs to build their capacity and attract the finance to make this transition. So, what practical steps can be taken to create an environment where climate action and access to energy are congruent goals in LDCs?

Our organisation, the Climate Technology Centre and Network (CTCN), the operational arm of the UN Climate Convention's Technology Mechanism, is co-hosted by UN Environment and the UN Industrial Development Organization (UNIDO). It focuses on providing solutions to such questions by matching developing country needs for climate technologies with funded, tailored, world-class solutions provided by our global network of 450 technology companies and institutions.

Since our inception, we have worked alongside LDCs to help them implement their national climate and energy strategies. We do this through interventions that enable supportive policies, by building local capacity to manage transformative technologies, and by helping LDCs to access international financial mechanisms.

In Nepal, the CTCN supported the development of a policy framework and business model to promote the sustainable use of biomass briquettes. This assistance will ultimately help the country achieve its national development priorities by addressing energy needs from various consumer levels. It will reduce excessive fuel wood consumption for cooking and heating in rural households. It will decrease dependency on forest resources. And it will boost employment in the biomass energy sector.

In Uganda, we facilitated a feasibility study for a national pay-as-you-go policy and mechanism to enhance rural off-grid solar energy access and clean cook stoves. Following the study's recommendations, the country has developed a national framework for mobile banking energy solutions. In Tanzania, the CTCN raised end-user awareness of solar photovoltaic technology, trained solar installers and retailers, and established a reference service as part of our assistance in promoting the sustainable use of this technology.

In Bangladesh, we helped develop a certification course for energy managers and energy auditors. This not only decreased dependence on volatile and rising energy prices, it also increased energy security and self-sufficiency. Through a summer school at Radboud University in the Netherlands,

▲ Installing panels at one of East Africa's largest solar farms, Rwamagana District, Rwanda. LDCs' drive to increase climate technology transfer is often hampered by limited institutional and organisational capacity

the CTCN provided tailor-made training to introduce the practice of technology transfer. Students worked in small groups on case studies focused on prioritising sectors and technologies for mitigation within different country contexts, and utilising policies and relevant governance tools. Of the 28 participants in the 2018 course, 14 were from LDCs.

To further assist LDCs to access international financial mechanisms, CTCN has introduced an incubator to support the development of requests for technical assistance in line with country technology roadmaps and support programmes. This allows countries to make better use of country-level finance available through the Green Climate Fund (GCF) readiness support programme.

Tanzania is the most recent LDC beneficiary of the incubator, receiving in-country training designed to enhance the skills of project proponents, ministries and institutions in preparing GCF concept notes. Of the three concept notes developed during the training, one focused on addressing the barriers of integrating mini-grid connection to the grid system.

Innovative approaches

These programmes certainly provide support to LDCs in acquiring the knowledge, skills and tools to finance and implement clean technologies. Yet findings from a recent paper published by the International Institute for Environment and Development on LDC experiences with the UNFCCC technology mechanism indicate that more outreach is required.

LDC representatives still feel that lack of capacity, awareness or information is their primary barrier to accessing climate finance for technology development and transfer. Others express difficulties related to the complexity of the process, noting the large number of steps involved in applying for and accessing funding. The more difficult the process, the more capacity countries need to navigate it.

In other words, we must work harder to stimulate collaborative international efforts and continue to strive for transformational change through innovative approaches. The CTCN continues to adapt its service offering to match not only the lessons learned from pilot projects and programmes but also from its National Designated Entities, report insights, network members and collaborative bodies. All of these are concerned with helping the most vulnerable populations in the world.

In the meantime, LDCs march on with innovative approaches. Bhutan, Cambodia, Ethiopia, Laos, Mozambique and Nepal have developed national low-carbon resilience plans and strategies. As their own action plans reveal, even if LDCs are facing enormous climate and energy-related challenges, the political will exists to take decisive action. We must act on this opportunity to introduce bold methods to reduce the energy access gap faced by LDCs, and simultaneously contribute to climate action. ●

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Accelerating clean energy transitions

The goals of the Paris Agreement are achievable but not if we continue on the current path

By **David Turk**, Head, Strategic Initiatives Office, International Energy Agency (IEA)

Energy-related CO_2 emissions increased 1.4 per cent overall in 2017, reaching a historic high. This, unfortunately, was a resumption of increases after three years of remaining flat, with most major economies experiencing a rise (notable exceptions include the United States, the UK, Mexico and Japan). Even more daunting, the IEA estimates that under current levels of policy ambition, including the nationally determined contributions under the Paris Agreement, the world will see a continued rise in energy-related emissions until at least 2040.

Our world needs to be on a very different trajectory, one that sees emissions peak in the near term and ramp down substantially after that – a trajectory like the IEA's Sustainable

◀ Petra Nova carbon capture, usage and storage (CCUS) facility at NRG Power Plant in Richmond, Texas, USA. CCUS is one of the technology areas where progress is falling short – Petra Nova is one of only two operating large-scale CCUS power projects in the world

Development Scenario. The scenario is not only fully in line with meeting the Paris Agreement's goals, it also satisfies two other critical Sustainable Development Goals (SDGs): achieving universal energy access by 2030 (SDG 7) and substantially reducing air pollution (SDG 3.9).

Long-term goals

Comparing our current trajectory to where we need to be can provide insights into what decision-makers need to focus on now in order to drive long-term clean-energy transitions. One such exercise is the IEA's Tracking Clean Energy Progress, a new web portal that examines progress across a full range of technologies and sectors – their most recent deployment rates, investment levels and innovation needs.

We find that only four out of 38 technologies and sectors were on track in 2017 to do their part to help meet the Sustainable Development Scenario. Of these bright spots, the most notable was the terrific expansion of solar photovoltaic, which by itself accounted for almost 14 per cent of electricity-generation growth. Electric vehicles also continued their strong proliferation, with sales jumping 54 per cent and total stock passing the three million mark. LEDs are another shining example, quickly becoming the dominant lighting technology sold in the residential sector. In 2010, LEDs had a one per cent market share. In 2017 it was 33 per cent.

Unfortunately, the vast majority of technologies and sectors are not on track to meet long-term sustainability goals, with very little sign of progress on 11 of the 38. For example, the number of large-scale carbon capture, usage and storage power projects in operation remained only two at the end of 2017. This was after the first gas-fired power plant project was shelved just before its scheduled start of operations.

The buildings sector – responsible for a third of final energy demand – also remains off track, with progress in efficiency improvements in building envelopes largely untapped. Two thirds of countries today do not have mandatory building energy codes, meaning that more than 40 billion square metres – more than the building stock in the United States today – will be built without mandatory policy coverage over the coming decade.

Finally, biofuels represented only about three per cent of transport sector fuel in 2017, significantly lower than their potential at a time of strong oil demand growth.

Two technologies – onshore wind and energy storage – which were on track to do their part in 2016, were downgraded in 2017. For wind, we have witnessed two consecutive years of declines in grid-connected onshore capacity additions. For energy storage, while battery prices continue to fall – by 22 per cent in 2017 – new installations of utility-scale electricity storage (excluding pumped hydro) remained flat in 2017, at around 620 MWh. To achieve the Sustainable Development Scenario, 80 GW of overall storage capacity would need to be added by 2030.

Innovation and ambition

Well-designed and ambitious policy remains key for all of these 38 technologies and sectors. Innovation – both by the public and private sector – is also absolutely critical. While many clean-energy technologies are cost competitive (and others quickly becoming so), innovation efforts will need to continue to ensure that the more mature green technologies are fit for purpose in all markets and geographies. Less mature technologies will need even more research and development attention, especially by the public sector.

On a brighter note, 2017 saw some good news on the innovation front. Our initial estimate shows that total public investment on low-carbon energy technology innovation rose 13 per cent, to more than $20 billion. Mission Innovation – an effort by 23 countries and the European Commission to double clean-energy innovation investment over five years – seems to be achieving results. On the private-sector part of the equation, innovation investment has seen around five per cent annual growth over the past five years. Further building upon these trends will require sustained government and private-sector leadership from countries, companies and investors around the world.

But it's not enough to simply invest more in clean-energy innovation: it also matters on what and how. With this in mind, the IEA has identified 100 'innovation gaps' that need further attention across all 38 key energy technologies and sectors. The gaps include, for example, the improvements needed for a wider range of storage technologies to become cost-effective, such as low-cobalt, low-lithium content batteries. We also need breakthrough cement production processes, small modular nuclear reactors, advanced geothermal systems and better vehicle materials, to name just a few.

It's not enough to simply invest more in clean-energy innovation: it also matters on what and how. The IEA has identified 100 'innovation gaps' that need further attention across all 38 key energy technologies and sectors

In addition, the IEA is working intensively with countries around the world on the 'how', including a new effort in India to help channel global best practices to improve their clean-energy innovation ecosystem.

While countries and companies around the world are making some notable progress on clean-energy transitions, the task facing all of us remains enormous. The good news is that we are getting better at providing the needed data, rigorous analysis and real-world solutions – but so much more is necessary. The IEA will be actively doing its part to help. ●

The climate cost of food

We must change the way we produce and consume food if we are to protect the climate

By **Pramod Aggarwal** and **Shehnab Sahin**, CGIAR Research Program on Climate Change, Agriculture and Food Security, Borlaug Institute for South Asia–International Maize and Wheat Improvement, New Delhi, India

The benefits of a well-balanced diet on health are well known. Public awareness is higher than ever, with much written and spoken about the positive effects of vegetarianism, veganism, organic and superfoods, the ketogenic diet, and so on. However, the climate dimension of food is less well understood: what we eat both affects and is affected by the climate.

Several studies – including by the Intergovernmental Panel on Climate Change (IPCC) – have highlighted the impact of climate change on food production and prices. This affects food availability, affordability and consumption – and ultimately human health. Recent studies have expanded these analyses to include repercussions on micronutrients like zinc and protein, including in legumes and vegetables.

It is estimated that by 2050 elevated carbon dioxide (CO_2) could cause an additional 175 million people to be zinc deficient and an extra 122 million people to be protein deficient. There are other effects to consider too. For example, climate-induced deficits in food production could lead to more international food trade, in turn generating more greenhouse gas (GHG) emissions from the transport and logistics sectors.

The climate cost of food is well documented. Agriculture and land-use systems are responsible for up to 30 per cent of anthropogenic GHG emissions and about 70 per cent of freshwater use. The sector produces the largest share of non-CO_2 emissions, including methane and nitrous oxide from livestock, manure management, fertiliser use, rice cultivation and agricultural soils. But it also accounts for CO_2 emissions through the burning of crop residues and savannah, for instance, as well as processes such as shipping. While emissions occur throughout the different stages of the food chain – production, transportation, processing, preparation and storage – the intensity varies across the stages depending on the part of the world. In developing countries, like India, emissions mostly happen at the food production stage. In most developed countries that have a high affinity for processed food, emissions can be attributed mostly to the ancillary stages.

Animal-based foods are major contributors to these problems. Meat production, mainly beef, contributes most to GHG emissions. More specifically, enteric fermentation – where livestock produce methane during digestion and belching – accounts for the largest source of GHG emissions from the agriculture sector. The carbon footprint of a Big Mac cheeseburger stacks up at 4 kg of CO_2 equivalent (CO_2e) gases, which in turn translates to nearly two litres of petrol. Producing 1 kg of turkey meat is equivalent to 10.9 kg of CO_2e. When considering all the GHG emissions caused by a food product, ruminant meat has the biggest carbon footprint, followed by seafood, eggs, poultry and plant-based food.

> ***A completely plant-based diet would lead to very different outcomes in developed and developing parts of the world***

Against this backdrop, is it prudent to divide dietary choices into the classical binary of vegetarianism versus non-vegetarianism, ascribing planet-saving potential to one over the other? The situation is more complex than we think.

A number of recent studies point towards the positive environmental consequence of a dietary shift to vegetarianism. Researchers from Oxford University recently estimated that a global shift to vegetarianism by 2050 would lead to a drop of GHG emissions by about 60 per cent. Lowering meat consumption would also mean that more land becomes available for farming, and that there is less of a need for expensive climate mitigation.

However, we must look at the spectrum of impacts of a dietary shift to vegetarianism. Such a shift would have significant impacts on the food web as a whole, as food chains are interlinked and often interdependent. It would also affect the wider ecological cycle.

The full environmental cost across the entire food value chain also needs to be explored. For example, half of humanity consumes rice. The IPCC suggests that agriculture is responsible for approximately 50 per cent of global methane emissions, with rice accounting for 11 per cent. It takes approximately 3,000 litres of water to produce just 1 kg of rice. Then there are the additional environmental costs associated with producing fertilisers, processing the rice, marketing, and so on. So if we are to make the farming of crop-based food products sustainable and less damaging to the environment, farming techniques must change. Rice farming, for instance, could use the 'alternate wetting and drying' technique. This reduces the amount of time rice fields are flooded, lowering the production of methane by about 60 per cent.

In addition, we must consider whether a sudden shift to plant-based diets is feasible from a socio-economic point of view. A completely plant-based diet would lead to very different outcomes in developed and developing parts of the world. While

▲ On the slopes of Mount Nemrut, Turkey, shepherds herd livestock to their village for milking. Caution is needed when advocating a complete and sudden shift to plant-based diets. Millions depend on animal farming, particularly those who live in semi-arid or arid rangeland

the environmental and health benefits in developed countries may be more pronounced, in developing countries such a shift may in fact exacerbate poverty. Millions of people are dependent on animal farming as a sole means of livelihood, especially when you consider that a third of the world's land is semi-arid or arid rangeland.

Everything in moderation

So, can we cut GHG emissions by simply changing dietary patterns? The research suggests that it is certainly possible to reduce emissions through shifting to locally produced fresh food, moderating meat and dairy consumption, consuming more vegetable protein, shifting from ruminants to poultry, and so on. But all of this will count for little if we continue to produce food that causes very high emissions.

What, then, are the most important recommendations to infuse sustainability into food production and consumption, and reduce its climate cost? First, moderation is key. Global studies have found that limiting meat intake and simply adhering to the World Health Organization's dietary recommendations would bring down emissions – by as much as 17 per cent in developed countries such as the UK.

Reducing food waste is another solution with colossal significance. Every year 1.3 metric gigatons (1.3 billion tonnes) of edible food goes to waste, according to a 2017 study from the University of California. Nearly 6.7 per cent of all global GHGs come from food waste, according to the UN's Food and Agriculture Organization. Addressing this issue, therefore, holds immense potential in dealing with the climate cost of food.

More fundamentally, we need to move towards climate-smart agriculture (CSA). CSA is an approach that aims to increase agricultural productivity sustainably; support equitable increases in farm incomes, food security and development; adapt and build resilience of agricultural and food security systems to climate change at multiple levels; and reduce GHG emissions from agriculture wherever possible.

Precision farming is one CSA practice. It involves a more precise application of essential nutrients like nitrogen on crops, which significantly lowers emissions and runoffs without affecting yield. Precision farming also adheres to the principles of conservation agriculture. As well as encouraging efficient use of water and nutrients, conservation agriculture promotes diversification of plant species, soil conservation and enhancement of natural biological processes. Greening the way we power our farms through solar energy is also a promising way to mitigate emissions while boosting farm incomes.

And we need participatory evaluation platforms for making informed choices on sustainable agricultural practices. The climate-smart village approach of the CGIAR research programme on Climate Change, Agriculture and Food Security is one such platform that transforms villages and landscapes into sites for testing technological and institutional options. These villages generate evidence of the effectiveness of CSA in a real-life setting. Above all, we need the constant convergence of science, policies and politics to usher in sustainability in the global food system. ●


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Protecting climate by protecting nature

Curbing global temperature rise will require removing more carbon from the atmosphere than we release into it. How can we harness natural ecosystems to help achieve this?

By **Sandeep Sengupta**, Global Coordinator – Climate Change Portfolio, and **Juha Siikamäki**, Chief Economist, International Union for Conservation of Nature

Climate change is one of the most pressing challenges confronting humanity today. Nature faces the effects of climate change, but it also plays a much broader role in it. Depending on how the world's ecosystems are managed, they can either contribute to the problem, or provide effective nature-based solutions to solving it.

Contributing to the climate problem, the loss and degradation of forests alone currently constitute around 12 per cent of human-caused carbon dioxide (CO_2) emissions. The land sector as a whole, including agriculture, forests and other land uses, is responsible for nearly a quarter of global emissions.

However, we now know that the avoidance of these emissions through better conservation and land management actions offers a feasible, cost-effective option that is available in the near term. Moreover, restoring degraded lands and enhancing existing ecosystems can help absorb additional CO_2 generated from other sectors. It has been estimated, for instance, that restoring 350 million hectares of degraded or deforested landscapes by 2030 could sequester between one and three billion tonnes of CO_2 per year while also generating about $170 billion per year in other benefits from ecosystems. Managing nature well can thus make a significant contribution towards global climate mitigation efforts.

Nature's centrality to climate change can also be gauged from the fact that about 60 per cent of cumulative greenhouse gas (GHG) emissions from human activities since the pre-industrial era have been stored either on land (in plants and soils) or in the ocean. Terrestrial ecosystems store almost three times the amount of carbon found in the atmosphere, while oceans absorb over 25 per cent of annual CO_2 emissions. Better conservation, restoration and management of ecosystems – be they forests, wetlands or oceans – play a critical role in the healthy functioning of the carbon cycle and the balanced regulation of the planet's climate.

Nature-based climate solutions

In research published last year, a group of leading experts identified and quantified 20 primary conservation, restoration and improved land management pathways that can increase carbon storage and avoid GHG emissions across global forests, wetlands, grasslands and agricultural lands. Their study, called *Natural Climate Solutions*, found that the potential of these nature-based climate solutions – even when restricting them by adding safeguards for food and fibre security, and biodiversity – is more than 30 per cent greater than previously thought.

The study also examined whether nature-based climate solutions are cost-effective – that is, available at cost comparable to

◀ **Harvesting peat in Tipperary, Ireland. Peatlands are one of the world's most valuable ecosystems and the largest terrestrial carbon store. Damage to peatlands globally is estimated to release 1.3 gigatonnes of CO_2 per year, equivalent to 5.6 per cent of anthropogenic emissions**

mitigating emissions from other sectors of the economy, such as the energy, transportation and household sectors. The findings show that these natural climate solutions are tremendously potent, providing an estimated 37 per cent of cost-effective mitigation needed between now and 2030 to hold global warming below 2°C.

Ecosystems, of course, vary in their capacity to store and sequester carbon. Of all ecosystems, forests have the greatest amounts of cost-effective mitigation opportunities to offer, making up about two thirds of all nature-based climate solutions globally. Within the forest sector, reforestation offers the largest potential to mitigate climate change, followed by avoided deforestation and improved forest management.

Grassland and agricultural pathways offer about one fifth of nature-based solutions to hold warming below 2°C, with cropland nutrient management, inclusion of tree cover in croplands, and conservation agriculture as key activities. In the livestock sector, improved feed and animal management has considerable potential to reduce methane emissions.

Wetlands are not as extensive as forests and grasslands, but on a per unit-area basis, they hold the greatest volume of carbon. Research on mangroves, for example, indicates that preserving them is justified in most places around the globe solely on the basis of carbon storage, even without considering the broad range of other benefits they provide. These include safeguarding coasts, protecting fisheries, regulating water quality, and providing wood and habitat for wildlife.

Ecosystems not only help to mitigate climate change, but also add to climate resiliency and adaption. For example, wetlands helped to avoid over $600 million in direct flood damages during Hurricane Sandy in 2012. More generally, coastal wetlands in the US have been estimated to provide storm protection services worth $23 billion annually.

Additional benefits

Besides climate benefits, most natural climate solutions offer a broad range of other benefits, including water filtration, flood control, soil health, livelihood support and biodiversity habitat. Similar to the climate benefits of nature, they too are available in the near term through improved management and conservation of nature.

The Paris Agreement, adopted by 195 countries and the EU in December 2015, sent a clear signal of the vital importance of the world's ecosystems in achieving climate neutrality over the course of this century. The Agreement directly calls on countries to appropriately conserve and enhance natural carbon sinks and reservoirs of all types – biomass, forests and oceans, as well as other terrestrial, coastal and marine ecosystems – to fully harness their mitigation potential.

International acknowledgement

Several countries have also recognised the role of ecosystems in climate adaptation and in enhancing resilience (for example, through mangrove restoration for coastal protection), with some 20 countries including explicit references to 'ecosystem-based adaptation'. These actions clearly testify to the growing international acknowledgement of nature-based solutions to climate change.

Even in the context of climate change assessments, the Intergovernmental Panel on Climate Change report released this October paints a particularly challenging future. Human activities have already caused the climate to warm by approximately 1°C on average worldwide from the pre-industrial era. The current rate of emissions will lead to that number rising to 1.5°C in the near term, possibly as early as 2030.

Besides climate benefits, most natural climate solutions offer a broad range of other benefits, including water filtration, flood control, soil health, livelihood support and biodiversity habitat

The Agreement also clearly acknowledges the role that healthy ecosystems play in building resilience, and the need to take vulnerable ecosystems and communities into account in national adaptation planning and action. It notes the importance of ensuring the integrity of all ecosystems, including oceans, and the protection of biodiversity when acting to address climate change.

At the national level, a growing number of countries have started incorporating ecosystem-based mitigation and adaptation measures within the nationally determined contributions they submitted in support of the Paris Agreement.

An analysis conducted by the United Nations Framework Convention on Climate Change in 2016, for example, showed that over 70 per cent of countries specified forest/land-based mitigation measures within their submissions. Specific examples include: China pledging to increase its forest stock volume by 4.5 billion m^3 over 2005 levels by 2030; India pledging to create an additional carbon sink of between 2.5 and 3 billion tonnes of CO_2 through additional forest and tree cover by 2030; and Mexico pledging to achieve zero per cent deforestation by 2030.

In the absence of effective mitigation policies, the world faces 3°C warming by the end of the century, along with potentially disastrous outcomes to people and nature alike. This points to a need for urgent and ambitious action to curb global emissions from across all levels and sectors of society.

Maintaining global warming below 1.5°C would considerably reduce the harm from climate change, but this will require large emission reductions in the near term. First, we will need to transition to zero net emissions globally. Then we will have to find ways to achieve negative emissions: sequestering more CO_2 from the atmosphere than is released into it.

Nature-based solutions can play a vital role in this regard in helping the global community, particularly in the near term, to achieve the longer-term objective of a decarbonised global economy. ●

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A child sits on his mother's lap at Banadir hospital in Mogadishu, Somalia, on March 9, 2017. Today's generation of young people is the largest in the history of the world – between now and 2030, the target date for achieving the Sustainable Development Goals, half the world's population will be under 30, with much of that growth taking place in Africa. We must harness this staggering human potential, not only by ensuring that nobody is left behind, but also by ensuring that everyone's voice is heard in global governance structures.

UNA-UK

The road to cleaner transport

Transport keeps the wheels of our economy turning but is also a major source of emissions. What is the role of policy in creating a transport sector that is fit for a low-carbon economy?

By **Raffaele Mauro Petriccione**,
Director-General, European Commission
Directorate-General for Climate Action

Transport represents almost a quarter of Europe's greenhouse gas (GHG) emissions and is a major cause of air pollution in cities. Low-emission transport is therefore essential for meeting our 2030 climate and energy targets and our commitments under the Paris Agreement on climate change – as well as our contribution to achieving the Sustainable Development Goals by 2030.

The low-emission mobility strategy adopted by the European Commission in July 2016 set a clear ambition: by mid-century, transport GHG emissions will need to be at least 60 per cent lower than in 1990, and firmly on the path towards zero.

However, it is now clear that even this goal would not suffice for the EU to do its part towards meeting the goals of the Paris Agreement. Therefore, while the measures proposed by the Commission retain their purpose, they now must be seen as an intermediate step towards a more ambitious goal. To this end, the Commission will present its vision of a long-term strategy for a low-carbon economy by the end of November 2018, thereby fulfilling requests by the European Council and the European Parliament. The Commission has put forward three sets of legislative proposals and policy measures that aim to ensure a socially fair transition towards clean, competitive and connected mobility for all Europeans.

Emission standards for new cars, vans and lorries

In the road transport sector, key measures include proposals for new CO_2 emissions standards for cars and vans and the first-ever EU standards for CO_2 emissions from lorries. These will be a cornerstone of EU action. Other measures the EU is taking include promoting clean vehicles in public procurement and developing an infrastructure for alternative fuels.

The EU was among the first jurisdictions to set ambitious CO_2 emission targets for cars, in 2009. The 2015 and 2021 targets represented reductions of 18 per cent and 40 per cent respectively compared with the 2007 fleet average emissions.

While we have seen a steady reduction in emissions from new cars and an accelerated uptake of innovative fuel-saving technologies, road transport emissions have not decreased as expected. This is for a number of reasons, including a growing vehicle stock. But it is also due to the growing gap between type-approved emission values measured in the laboratory and real-world emissions.

The Commission's proposal for new CO_2 standards aims to bring further emission cuts and boost the share of zero and low-emission vehicles after 2020. For both new cars and vans, the EU fleet-wide average CO_2 emissions will have to be 30 per cent lower in 2030 than in 2021. The proposal sets an intermediate reduction target of 15 per cent for 2025. This is crucial to ensure investment starts now, while the 2030 target gives the long-term direction. The proposal also includes an innovative incentive system to make sure manufacturers deploy zero and low-emission vehicles. Action in Europe will help stimulate the uptake of clean vehicles in other parts of the world.

In addition, the Commission has proposed introducing EU-wide CO_2 emission performance standards for lorries. The EU is the only large economy not yet regulating CO_2 emissions in the heavy-duty vehicle sector, even though emissions from lorries have risen in recent years and currently account for a quarter of EU road transport emissions. At the same time, many readily available technologies to improve fuel efficiency are not deployed in the market, despite low costs and high net savings potential.

Setting emission standards at EU level is therefore important to deliver on our climate objectives. It will also contribute to improving competitiveness and reducing fuel costs for transport operators, most of which are SMEs. Both the proposals – on cars and vans, and on lorries – allow for a smooth transition to zero and low-emission vehicles while also providing sufficient time for re-skilling and up-skilling workers in the automotive supply chain.

Tackling emissions from aviation

While road transport is responsible for the lion's share of transport emissions, those coming from international aviation and maritime transport are growing fast. These sectors also need to contribute their fair share to global efforts to fight climate change.

Aviation is one of the fastest-growing sources of GHG emissions worldwide. By 2020, international aviation emissions are projected to be around 70 per cent higher than in 2005. The International Civil Aviation Organisation (ICAO) forecasts that by 2050 they will grow by a further 300 to 700 per cent.

To tackle these emissions, the ICAO has so far agreed on two aspirational goals: first, a two per cent annual fuel efficiency improvement to 2050; and second, the stabilisation of CO_2 emissions at 2020 levels through a market-based offsetting mechanism called CORSIA.

Negotiations on the system's key aspects are ongoing and the EU is actively involved.

▲ Copenhagen, Denmark, has a noteworthy approach to sustainable urban transport. Over 40 per cent of those commuting to work or education do so by bike

For the system to be effective, we will need robust rules and adequate participation, as well as other measures such as sustainable biofuels. A long-term goal for the sector would also be desirable.

Aviation has been included in the EU emissions trading system (ETS) since 2012. All major aircraft operators active in the European Economic Area – about 500 in total, including around 200 from countries outside the EU – are duly complying and benefiting from the system. The EU system will be reviewed in due course in light of international developments, while preserving its consistency with the EU's 2030 climate goals.

In addition to the ETS, the EU is also addressing aviation emissions through other measures, such as support for research, development and innovation, and work on sustainable alternative fuels. These all have the potential to help reduce emissions in the longer term.

Reducing shipping emissions

Shipping is a key enabler of globalisation and the backbone of the global economy. While shipping is in most cases more fuel efficient than other transport sectors, its absolute GHG gas emissions are substantial. They could increase by between 50 and 250 per cent by 2050, according to a 2014 study by the International Maritime Organization (IMO).

At global level, the IMO adopted an initial strategy in April 2018 aimed at reducing shipping GHG emissions by 50 per cent by 2050 compared to 2008. The strategy also seeks to achieve full decarbonisation as soon as possible during this century, as well as improving carbon intensity by at least 40 per cent by 2030. The sector now needs to put the strategy into practice through short, medium and long-term measures that will help emissions peak early and allow the sector to deliver on its goals.

In the EU, shipping is currently the only economic sector that is not directly addressed through a specific measure associated with an objective to reduce emissions, despite the fact that shipping emissions represent around 13 per cent of EU transport emissions. The EU adopted a legislative framework for monitoring, reporting and verifying shipping emissions in 2016, as the first step of a broader strategy. With the first reports due next year, the scheme will help collect robust data. By making the data publicly available, the scheme is expected to create incentives for greener ships and energy-efficient practices.

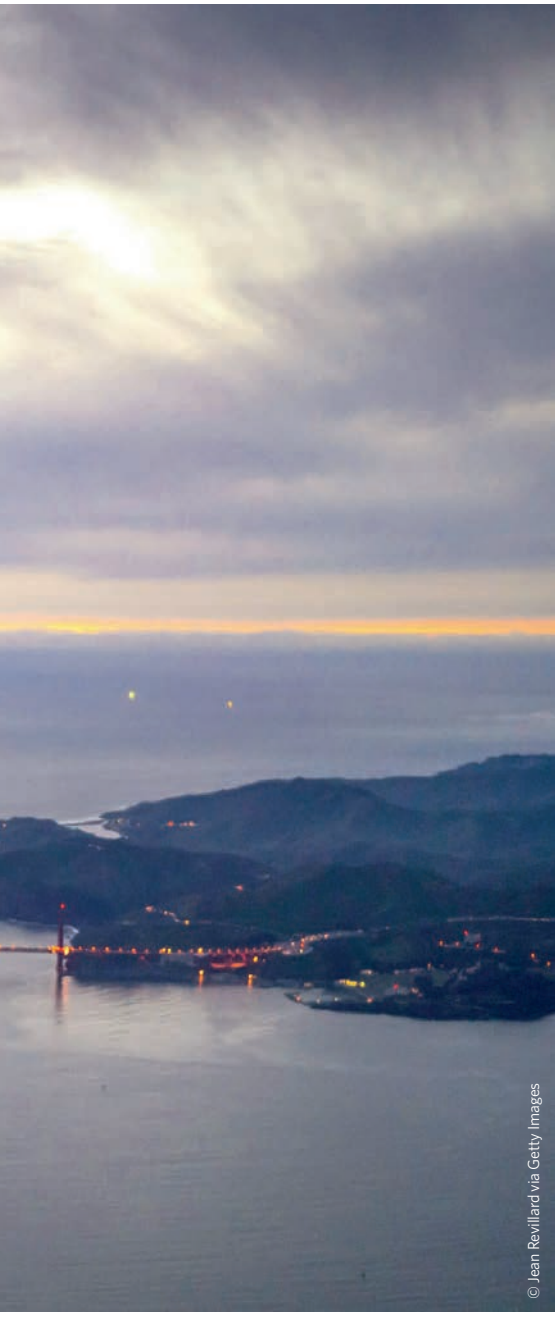
Joined-up approach

Across all sectors of the EU economy, the decarbonisation challenge is not just about hitting our climate targets. It is also about transforming our entire economy, beginning with our energy system, while strengthening our competitiveness and innovation power.

Making the most of this transition requires a comprehensive approach. All parts of the transport sector and all stakeholders will play a role – from parts suppliers to vehicle manufacturers, energy and fuel providers to technology developers, infrastructure managers to end consumers. We can only realise the full potential of clean energy and low-carbon transport if we work together. ●

How to decarbonise transport

Transport emissions are demonstrating stubborn growth. What are the alternative technologies to make mobility sustainable and universally available?


© Jean Revillard via Getty Images

◀ The solar powered 'Solar Impulse 2' over San Francisco, after a flight from Hawaii during its circumnavigation of the globe. Aviation is particularly problematic as alternative fuels can't match the energy density of hydrocarbons

By **Nigel Brandon**, Dean of Engineering, Imperial College London; Director, UK Hydrogen and Fuel Cell Supergen Hub; and Co-Director, UK Energy Storage Supergen Hub

Developed economies have evolved around ubiquitous access to transport – be this cars, trains, ships or planes. Yet for many parts of the world access to any form of modern transport remains an unrealised ambition. In Africa, for example, around 450 million people are estimated to have little or no access to transport infrastructure. This impacts people's quality of life and hinders development. It should therefore be a global ambition that mobility is equally available to all. Indeed, this links to a number of the Sustainable Development Goals adopted by world leaders in 2015, including the goals on health, energy, resilient infrastructure, and sustainable cities.

Yet at the same time as we harbour this ambition, emissions from the transport sector continue to grow. It has been forecast that between 2015 and 2030 annual passenger traffic will increase by 50 per cent and global freight volumes by 70 per cent, and that an additional 1.2 billion cars will be on the road. In 2012, transport was the largest energy-consuming sector in 40 per cent of countries worldwide. The sector currently contributes 23 per cent of global energy-related greenhouse gas (GHG) emissions and 18 per cent of all human-made emissions. Indeed, there is increasing concern over the environmental and associated health impact of transport emissions, such as nitrogen oxides, particulates and volatile organic compounds, which reduce air quality in our towns and cities.

Road transport is the largest contributor to global carbon transport emissions, at around 75 per cent. Air and water-borne transport make up most of the balance. The growing concern over road transport emissions has led to locally implemented low-carbon or zero-emission zones in some cities, and regulations in some regions to influence vehicle carbon emissions. For example, the EU introduced new regulations on CO_2 emissions from new cars and vans in 2009 and 2011 respectively, driving industry investment to improve fuel efficiency.

Different fuels

Governments in some countries have made ambitious statements on transport, such as the UK Government's recent commitment to end the sale of new conventional petrol and diesel cars and vans by 2040. And the UN's International Maritime Organization has recently approved the first agreement to cut GHG emissions in the shipping sector to 50 per cent of their 2008 level by 2050.

Faced with these challenges, what choices exist? Of course, we already have some zero-carbon and zero-emission transport options (walking and cycling), and there are policy measures in place in many economies to encourage a greater shift to these modes.

We also have options to reduce the growing demand for transport, such as home working and video conferencing. All this helps reduce demand. But none of it is sufficient to eliminate our current dependence on energy-dense fossil fuels for most of our transport needs.

Governments in some countries have made ambitious statements on transport, such as the UK Government's recent commitment to end the sale of new conventional petrol and diesel cars and vans by 2040

The solution lies in moving to different fuels:

- Biofuels: these are liquid fuels, such as biodiesel, generated from biomass or waste. Biofuels can have a positive carbon impact and avoid competition with land use for food production if produced correctly. But once burnt in an engine they can still result in unwanted environmental impacts. There are valid concerns that biomass resources could be better targeted at the production of biochemicals to replace chemicals currently produced from oil.
- Electricity: if generated from low-carbon sources such as renewables, electricity can be used to fuel emission-free and

quiet electric vehicles (EVs). These are now commercially available, and over 300,000 plug-in EVs were sold in the first quarter of 2018, with sales in 2017 representing 1.3 per cent of all new vehicles. The sector will continue to grow as battery technology improves, and as manufacturer and customer confidence evolves through use.

- Hydrogen: if generated through low-carbon means (either from fossil fuels with carbon capture and storage or by electrolysis of water using electricity generated from renewables) then the only emission from hydrogen-powered fuel cell vehicles is water. A relatively small number of these vehicles are currently available, with just over 1,000 delivered in the first quarter of 2018. Growth is constrained by both manufacturing capacity and the availability of hydrogen refuelling stations.

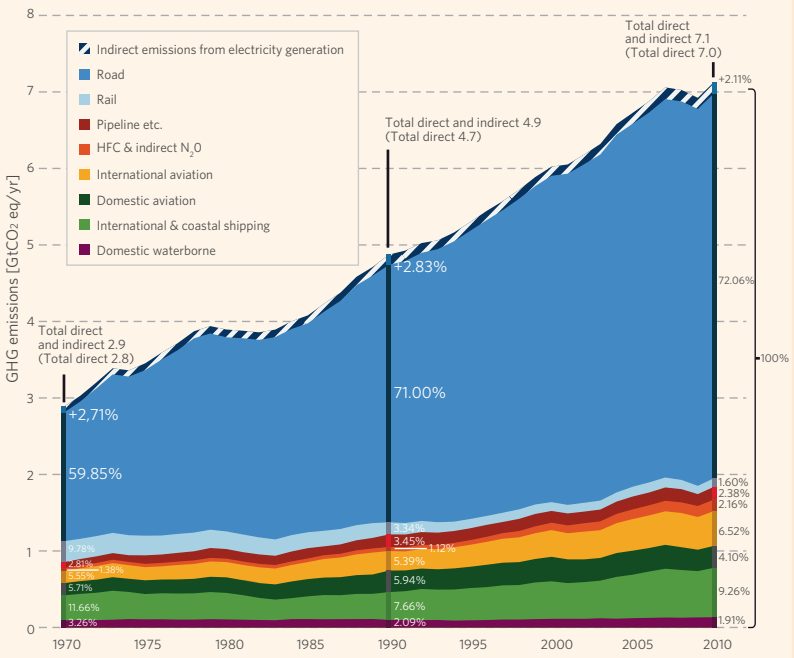
Where does this leave us in terms of our transport choices, and what may be the best options going forward? For light-duty transport such as cars and vans, it seems best to focus on low-carbon electricity and hydrogen. Battery EVs can now offer ranges approaching 300 miles, though these vehicles remain relatively expensive today. Costs will fall as we learn more about the technology, and as battery research and development continues to advance.

Hydrogen vehicles are emerging and offer fast refuelling (similar in time and process to conventional fossil fuels) and a range of around 300 miles with current technology, though costs are also high at present.

For long-distance and heavy-duty vehicles, the energy density of the fuel becomes more important. The volumetric energy density of a liquid fuel such as gasoline or biodiesel is currently around 30 times higher than a lithium ion battery, and around three times higher than compressed hydrogen. This illustrates the challenge facing battery (and to some extent hydrogen) EVs when long range is needed, despite the significantly greater efficiency of EVs over those based on internal combustion engines.

So, it is difficult to envisage the majority of HGVs, ships and planes being powered on electricity alone. Here the most likely options are the use of biofuels and hydrogen – the former in particular for the most energy-dense applications, such as aircraft. For buses and some heavy-duty vehicles, hydrogen also becomes an attractive option. This allows us to focus our biomass resources onto the most challenging transport applications.

Transport sector direct greenhouse gas emissions



Note: Indirect emissions from production of fuels, vehicle manufacturing, infrastructure construction etc. are not included *Source: IPCC 5th Assessment Report*

A shift to clean transport

Our transport system of the future is therefore likely to rely on a mix of biofuels, electricity and hydrogen. The balance between these is difficult to predict, but for the reasons discussed different fuels are very likely to be more dominant in different sectors.

To achieve this we need to invest not only in the transport technologies themselves, but also in the infrastructure that supports them, including electric charging points, electricity generation and distribution systems, hydrogen refuelling, low-carbon hydrogen generation and the production of biofuels.

These will all require support from governments, together with consumer engagement – and much learning by doing. But none of it is too difficult. We have already seen the pushback against diesel fuels in many parts of the world. And many countries are recognising the potential competitive advantage of investing in and using these cleaner alternatives.

Local initiatives will be important in shifting public attitudes and motivation, and greater awareness of the health impacts will reinforce this. Fossil fuels will continue to be an important part of the transport mix for some years to come, not least because vehicles sold today will remain in use for many years.

But once consumers can be offered clean transport choices without compromising cost and performance, then the shift to clean transport systems could happen very quickly indeed. ●

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New Jeep® Wrangler

New Jeep® Renegade

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New Jeep® Renegade

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UNA-UK thanks Fiat Chrysler Automobiles for its generous support for this publication

Greening infrastructure

Climate action requires a new paradigm for infrastructure projects that embeds ecological as well as societal benefits

By **Elisabeth M. Hamin Infield**, Professor of Regional Planning, University of Massachusetts Amherst

Current estimates suggest that over the next 15 years, global infrastructure requirements will cost at least $90 trillion. The Global South will account for about two thirds of that, just to meet urbanisation and population growth needs. Business-as-usual trends suggest that only about 80 per cent of that will be funded, although this varies substantially by continent. By contrast, achieving Sustainable Development Goal 6 – full access to clean drinking water and sanitation – would add a relatively modest $3.5 trillion.

But these numbers do not tell the whole story. Climate change means that existing infrastructure, which may seem good enough when judged on past conditions, simply isn't designed for the future. The gap in infrastructure is therefore a combination of projected needs, to achieve sustainable development, and increasing the resilience of infrastructure that is already built. There will need to be a whole lot of building if urban populations are to have basic services and be reasonably climate safe.

Infrastructure choices are also implicated in the ability to meet the goals set out in the Paris Agreement. There is broad consensus that infrastructure should include emission-reducing renewable energy, mass transit rather than roads, and energy efficiency in buildings. The materials used matter as well. Cement production accounts for five per cent of annual global greenhouse gas (GHG) emissions. A traditional approach to construction will only increase these levels. For example, protecting seaports from climate change would require 49 million tons of it. Meanwhile, trees and marshes store carbon, and other urban green space tends to be carbon neutral.

Hybrid projects

In recent years there has been an increase in what are called 'hybrid' infrastructure projects to improve coastal resiliency. These are projects that combine traditional grey structures with ecosystem and non-structural approaches. A good real-life example of a simple hybrid project is the addition of mangrove plantings to the rebuilding of a major roadway connecting Kingston, Jamaica, with its airport. The mangroves will serve as fish nurseries – good for the fish but also for the local fishermen – and will absorb some wave energy before waves hit the roadway.

Another, moderately complex, project was the 2015 construction of a new boardwalk on the touristic south coast of Barbados. Poorly designed jetties and other interventions had brought significant beach erosion. Hotel occupancy suffered as the beach eroded, with multi-storey buildings going vacant. The government could have responded by adding sand and sea walls, which would have been a quick but short-term fix. Instead, it selected a hybrid, soft shoreline approach using appropriate shoreline stabilisation and an integrated, well-designed boardwalk, which is slightly raised to allow for natural sand movement and sea-level rise.

The resulting boardwalk and beach are extremely pleasant and popular with both residents and visitors. Reinvestment has been steady as hotels recover and renovate. Hawksbill and leatherback turtles have been given protected areas of beach for nesting.

More complex projects are needed for larger areas. In the Caño Martín Peña neighbourhood in San Juan, Puerto Rico, for instance, thousands of residents lack connection to basic water and sanitary systems, and experience repetitive flooding during any major rainstorm. Plans call for green infrastructure such as floodable parks and bioswales to increase stormwater infiltration while providing public gathering spaces on dry days. Such green infrastructure reduces but does not eliminate the need for traditional sewer and water piping. Non-structural plans revolve around an active community-created land trust. The trust ensures that those who need to be moved out of the most flood-prone areas can get re-housed in the neighbourhood. More generally, it means that the improvements won't lead to gentrification displacing existing residents.

Hybrid projects have the potential for strong co-benefits far beyond the technical goals of structural approaches. Ecologies can be enhanced and shorelines protected with the addition or preservation of natural systems. These can be highly climate adaptive. New research is showing that if shorelines can have space over time, the dunes will add height and the salt marshes will move inland, building in climate resilience. Hybrid projects usually have lower embodied energy than their fully structural alternatives, as plantings are substituted for some concrete. And social benefits can be incorporated within the design fairly easily, improving land tenure security, local jobs and public health.

Change is hard

So if these kinds of projects are so great, why do many coastal and flooding projects still reflect standard structured engineering approaches? The most often-cited reason is cost, but there have been several studies to show that greener projects are, in fact, cost-competitive. A lack of education and

▲ Barranquitas, Puerto Rico: destruction in the wake of Hurricane Maria. As the frequency and severity of extreme weather events increase, the resilience of existing infrastructure needs to be enhanced

awareness are certainly factors. Engineers, planners, policymakers, politicians and funders need to be cognisant of advances in green and hybrid project design, and engineering codes need to be approved to support them.

Even when these issues are reduced, risk tolerance is likely to remain a barrier, from a variety of perspectives. It is riskier to design complex systems because we have less evidence-based knowledge of what exactly can be achieved with particular interventions over time. It is riskier for politicians to approve innovations that could fail. It is also riskier for institutions to fund them, in part because the distributed nature of the systems could make maintenance harder to plan, especially in situations with low civil capacity. In short, these are all different ways of saying change is hard.

There are plenty of studies looking at what it takes for organisations to innovate. At the most basic level, change requires an interruption of habitual process at an early stage – if it is too late, it is much less likely to have an impact. If hybrid projects are to become the norm, this path interruption needs to occur long before projects get to the stage of acquiring permits and cost estimation. Co-benefits need to be put on the same footing as other factors when project goals are first being conceived and initial designs are being sketched on napkins.

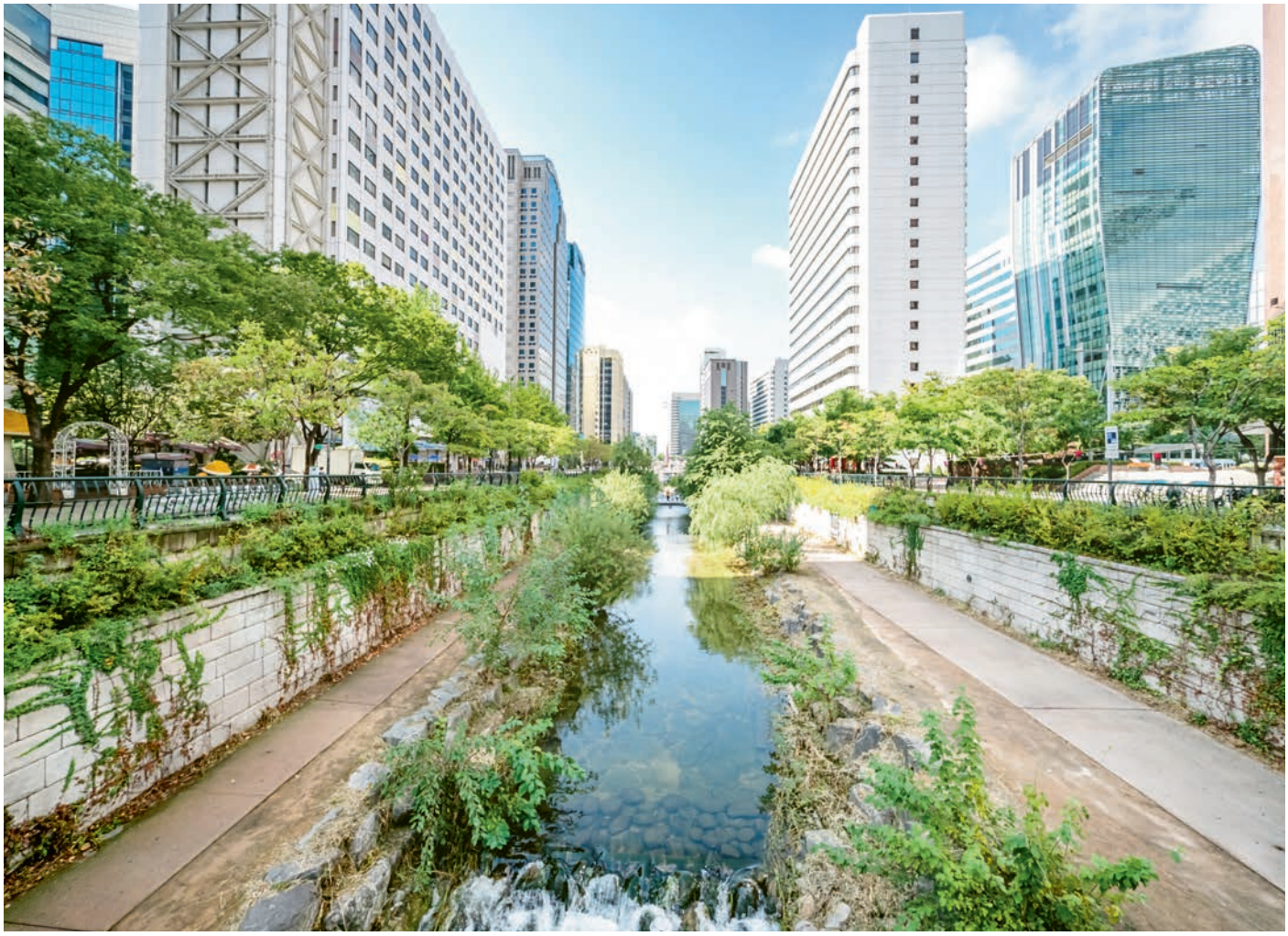
There are eight factors that should be included in any evaluation of preliminary project designs:

- cost efficiency;
- technical effectiveness in achieving project goals;
- GHGs;
- ecological enhancement;
- administrative and maintenance capacity;
- ability to adapt to changing climate and social conditions;
- the level and type of social benefits or equity improvements; and
- the anticipated participatory process.

These need to be present in requests for proposals and quotations documents, in funding mechanisms and in publicity releases. Indeed, they need to become normal considerations for infrastructure projects – small and large. If consultants know that projects will be evaluated across all these areas, they will design projects that achieve the range of benefits that are possible. They will present designs that are more complex and which achieve co-benefits as the baseline, rather than as a fluffy alternative.

As a result, constituencies will build projects that achieve wider sets of benefits now rather than in a distant climate future, and politicians will come on board.

With as much as $90 trillion and millions of lives at stake, infrastructure's climate and co-benefit potential cannot go untapped. ●



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How cities must change

By 2050, two thirds of the world's population will live in cities – they must become low or no-emission environments

By **Maryke van Staden**, Manager, Low Carbon City Agenda, ICLEI – Local Governments for Sustainability, and Director, carbon*n* Center

Stabilising global warming at 1.5°C is critical to prevent irreversible loss of biodiversity and secure our communities against dangerous weather and other harmful climate change impacts. This requires substantial and rapid change. The goals of the Paris Agreement can only be achieved if we intensify our efforts and implement high-impact solutions to reduce global greenhouse gas (GHG) emissions. Here the role of local governments in cities is key to define and implement the pathway of low-to-no emission development and climate resilience.

Cities contribute 70 per cent of the world's GHG emissions. Yet they are natural areas for local action, and also offer the best chance for reducing countries' per capita emissions, given their high population densities. The focus needs to be on switching to clean sustainable fuels, optimising energy efficiency, and planning our city spaces carefully. These approaches are relevant to both the Global North and South.

While local government leadership is vital, city halls are only likely to succeed if the right national policy frameworks are also in place. At ICLEI, we have long

◀ Cheonggyecheon Stream, Seoul, was the product of a massive regeneration project, which created an 11 km-long, public recreation space. Natural environments in cities like this improve air quality and cool neighbouring buildings

advocated for strong links between national and local policy. Four focus areas – derived from a study by ICLEI USA, *What's driving changes in local GHG emissions?* – outline some of the most important factors in urban climate change.

Battling urban sprawl

Urban sprawl occurs when cities grow in a way that disrupts the relationship between the amount of space a local government manages and the number of people it serves. It can occur for any number of reasons, including poor zoning or unfavourable market conditions.

Urban sprawl undermines the fundamental climate advantages of cities. When the distance between people becomes greater, so too does the cost of infrastructure designed to support them. Coupled with increased travel times for people living outside the city centre, sprawl also encourages higher emissions per capita.

To avoid urban sprawl, local governments need to create an environment that encourages denser development and settlement. This could, for example, take the form of an efficient public transport network constructed ahead of planned development. If people have ready access to public transit, it is more likely that the area will be developed in a more dense and efficient manner. Likewise, dedicating areas to green space will allow for more concentrated natural development, creating urban nature systems while minimising the risk that they will be built on later.

Dense development is not without challenges. But if we are to use cities as a tool for climate action, we must preserve their advantage of energy efficiency.

Making mobility more efficient

While dense development makes most forms of service delivery more efficient, there is an important counterpoint: street traffic. As cities become more densely populated, so do the streets. This has important implications for the environment: while vehicles in an urban environment are not driving further, they are certainly producing more emissions.

This is especially true for urban freight. When considering options for efficient transportation, municipalities and companies often do not provide adequate provisions for loading, unloading and deliveries in their territory. This leads to increased congestion and idling engines, often powered by diesel, that produce great volumes of carbon dioxide. In Argentina, where ICLEI's EcoMobility programme is rolling out, urban freight accounts for 40 per cent of the country's entire transport-related emissions.

By using more effective traffic systems, legislation, clean fuels and greener technologies, cities can greatly reduce local transport emissions. Ideally, local governments will use a 'systems perspective' to achieve improvements in mobility. Modern sustainable mobility systems can enable integrated mobility, with excellent public transport services connected to pedestrian and cycling zones, drawing people out of their cars.

Controlling the local climate

Anyone who has been in a hot metropolis during the summer can attest to the impact of asphalt on the local temperature, and the need to find shade. Cities concentrate materials that capture and radiate heat in a small area. This leads to energy being spent on cooling that could have been avoided if the local environment (or at least the buildings) were cooler.

One of the easiest, most cost-effective solutions for controlling spiralling temperatures is a natural one. Trees improve local air quality and combat erosion, but also provide a strong cooling effect on local neighbourhoods, reducing ambient temperatures in the surrounding buildings. This reduces the need for cooling and, as a result, reduces the city's energy consumption overall. In some neighbourhoods in Boston, USA, the loss of trees meant local energy consumption increased by nearly 20 per cent.

Local governments can use building codes to encourage the construction of better-insulated, more energy-efficient buildings. When new developments do not require as much energy to maintain their temperatures, they will be more environmentally friendly than their poorly insulated counterparts.

Dense development is not without challenges. But if we are to use cities as a tool for climate action, we must preserve their advantage of energy efficiency

Leading by example

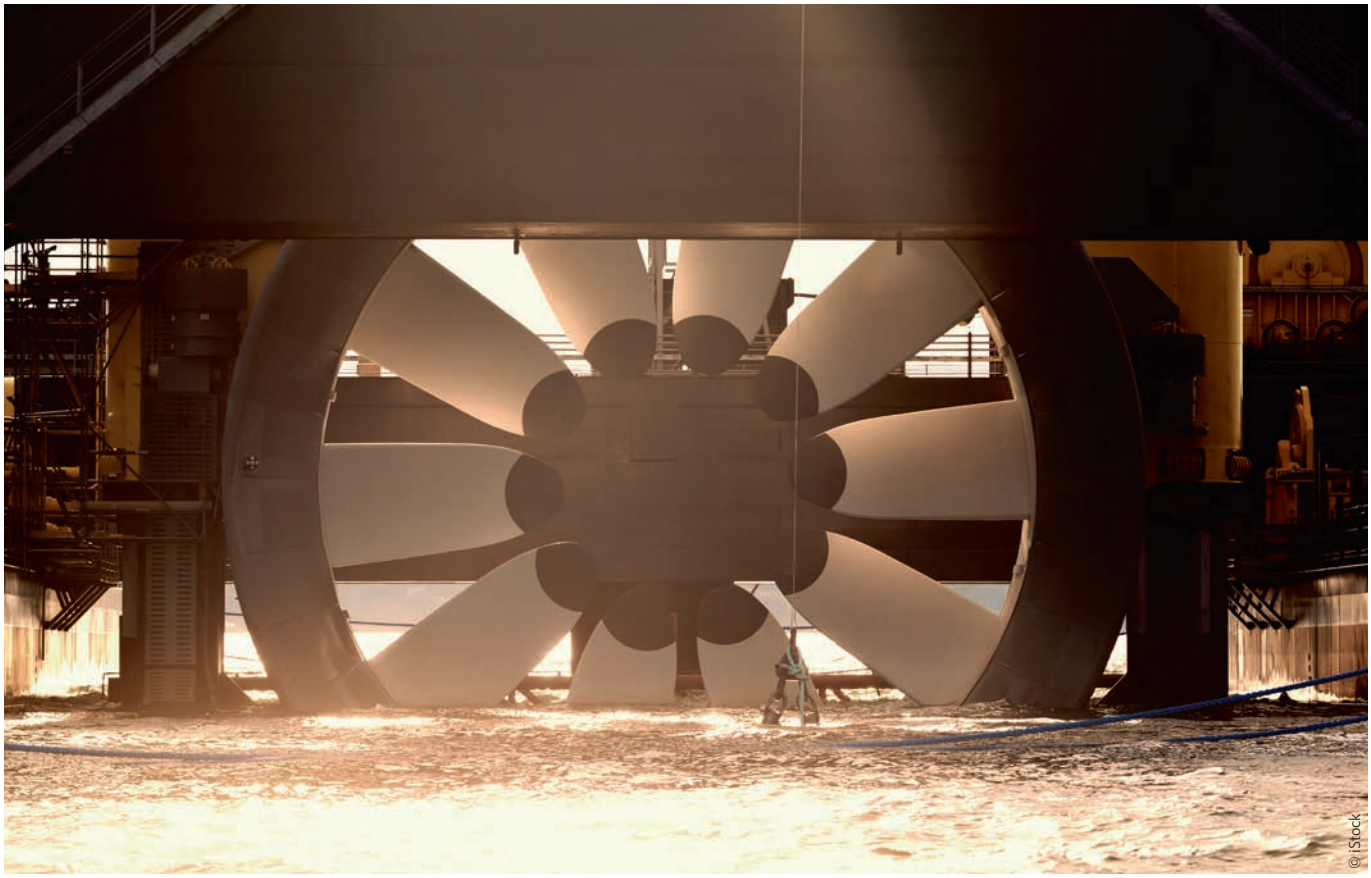
One action area for every local government to tackle emissions is in government operations. The substantial governmental purchasing power can be used to support ecologically friendly, carbon-neutral products and materials. Local governments are encouraged to set, monitor and achieve climate neutrality – including sustainable public procurement targets.

This could be as simple as using recycled paper in all municipal offices, or decisions on how to source electricity. It could even be where pension funds are invested (not in fossil fuels) to push the needle towards greener products and services across the board.

Regardless of the form it takes, local governments can make a huge impact on the market for sustainable materials by choosing them over less sustainable alternatives.

Making progress together

If city resources are mobilised, and if local governments are collaborative and well supported by their national governments, then the dramatic change we need to limit global warming to 1.5°C is within reach. ●



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Investing in our future

The creation of a truly sustainable economy will require businesses and investors to become more attuned to the planet's frailties and more responsive to public opinion

Hans Peter Portner,
Head of Thematic Equities, Pictet Asset Management

Danica May Camacho was born on 30 October, 2011, to the sort of fanfare rarely seen in Manila's crowded public hospitals. That's because she represented a global milestone – her birth brought the world's population to seven billion.

It was, without doubt, a joyous occasion.

But it also served as a reminder of the challenges posed by ever more people competing for the world's finite natural resources.

The arithmetic of population growth is certainly daunting. In less than 30 years' time, the planet will be home to nine billion human beings. And a larger proportion of them will form part of the middle class.

That is certain to put even more pressure on the environment, testing it to breaking point.

To their credit, governments are responding to this looming problem with well-designed policies.

But for the world economy to become truly sustainable, it needs its businesses – both large and small – to change their approach.

It's a major undertaking, not least because short-termism plagues corporate decision-making. Yet there are encouraging signs that companies could soon become the solution rather than the problem.

One catalyst for change in business behaviour is public opinion. Discontent with pollution and environmental damage is building. Surveys such as National Geographic's Greendex poll reveal that people are increasingly fearful of the impact environmental factors will have on their lives. Moreover, a growing proportion of the population has personal experience of the damage ecological degradation can cause. In 2015, pollution killed nine million people – three times more than AIDS, tuberculosis and malaria combined.[1]

◀ **A tidal power turbine on a test platform in Canada. Tidal power is in its infancy, a renewable energy resource with massive potential but high technological barriers**

Other studies consistently show that consumers are more likely to buy goods and services from companies that have strong environmental credentials and shun those that don't.

In response to public concern and more muscular environmental regulation, a growing number of companies are embracing what has become known as the 'circular' model of sustainable business.

Under this approach, firms are turning their backs on 'take, make and dispose' modes of production, and replacing them with processes that minimise waste, boost recycling and make more efficient use of land, raw materials and energy. The execution of such plans has generally been impressive.

Data compiled by Bloomberg New Energy Finance show that businesses and public agencies bought more clean energy than ever before this year, agreeing to purchase 7.2 gigawatts of clean energy so far in 2018, breaking the previous record of 5.4 gigawatts for all of 2017. Among the biggest purchasers were US corporate giants AT&T Corp, Walmart, Microsoft and Facebook.

Elsewhere, Dutch engineering group Philips and French auto maker Renault have each implemented policies under which they recondition parts – or entire products – that have reached the end of their useful lives so that they can be re-used or re-sold.

Renault says its auto remanufacturing plant at Choisy-le-Roi uses 80 per cent less energy and 92 per cent less chemical products than its traditional sites.

These are not isolated examples. According to the International Organization for Standardization (ISO), the body responsible for setting environmental benchmarks for corporations across the world, the number of firms achieving the required standards for sustainability has risen tenfold since the end of the last decade. Worldwide, there are now more than 350,000 companies that have received the ISO 14001 sustainable business certification.

Innovation and conservation

But businesses' role in safeguarding the world's natural resources isn't limited to embedding sustainability across their production and distribution chains. It also extends to ramping up investment into new environmental technologies.

Studies consistently show that consumers are more likely to buy goods and services from companies that have strong environmental credentials and shun those that don't

Speaking to US lawmakers in 1965, it was the then President Lyndon Johnson who warned that reducing humanity's ecological footprint would require "not just the classic conservation of protection and development, but a creative conservation of restoration and innovation".

Johnson did not live to see the technological progress he envisaged. But he might have been encouraged by what has unfolded over the past 10 years or so. In that time, a new industry of environmental products and services has begun to take shape.

With governments squeezing the fossil-fuel sector and corporations under pressure to embrace sustainable business models, investment has flowed into energy-saving and recycling technologies, renewable power and pollution control.

Evidence of this innovation can be seen in the sharp rise in the number of patents filed for environmental products over the past decade. Figures from the World Intellectual Property Organization (WIPO) show that patent filings for environmental technologies are running at an annual rate of 14,000 worldwide, more than double the number 10 years ago.

Energy efficiency is one area that has reached critical mass thanks to investments in new tech. In heavy industry, for example, energy is being saved by replacing traditional electric motors – which account for up to 70 per cent of a manufacturers' energy use – with smarter versions. It is estimated that every US$1 spent on this new breed of electric motor can result in a US$30 saving in electricity costs over the device's lifetime.

The efficiency drive is also evident in the world's cities. Electric public transport, energy-efficient residential and commercial buildings and street lighting are becoming a reality in urban centres right across the globe. The full implementation of energy-efficient technologies could cut energy costs by about US$17 trillion worldwide by 2050.[2]

Meanwhile, in agriculture, companies have commercialised a raft of sophisticated software and GPS guidance systems that promise to vastly improve the efficiency of farming and food production. Even if only 10 per cent of US farmers use GPS for planting seeds, it could save 16 million gallons of fuel, four million pounds of insecticide, and two million quarts of herbicide per year.[3]

Business part of the solution

To those sceptical of capitalism's capacity for change, sustainable business is a contradiction in terms. They'd argue that company executives, hounded at every turn by demanding shareholders, cannot realistically be expected to put protecting the planet on a par with profit growth.

Yet the notion that big business can never become a guardian of the environment is in need of revision. On a number of fronts, the corporate world is beginning to take its responsibilities seriously. ■

1 *The Lancet Commission on pollution and health, 19.10.2017*
2 *The Global Commission on the Economy and Climate*
3 *US Department of Agriculture*

Not just CO_2

Although carbon dioxide is the single-largest agent driving global warming, there are many others, many of which bring additional risks to health

By **Drew Shindell**, Nicholas Professor of Earth Sciences, Duke University, North Carolina

The Paris Agreement under the UN Framework Convention on Climate Change explicitly links the world's climate and sustainability agendas. Signatories aim to hold "global average temperature to well below 2°C above pre-industrial levels" while taking into account the "intrinsic relationship that climate change actions, responses and impacts have with equitable access to sustainable development and eradication of poverty".

Urgent action is clearly needed to achieve the climate goal, and the task is so challenging that the world needs to include all possible levers to slow warming. This means reducing emissions not only of carbon dioxide (CO_2), but many other pollutants as well. Fortunately, addressing a broader portfolio of pollutants can provide cost savings and multiple sustainable development benefits.

Though CO_2 is the largest single forcing agent, other compounds play a substantial role in driving climate change. Some, like nitrous oxide (N_2O), are long-lived greenhouse gases (GHGs) similar to CO_2 that persist for centuries. As fertilisers are a primary source of N_2O emissions, it may be difficult to greatly decrease emissions while also providing food and energy for a growing population – though overuse of nitrogen fertilisers should certainly be reduced significantly.

Other large drivers of climate change are much shorter lived. This implies that reductions in their emissions cannot substitute for reductions in CO_2, but also that benefits from such cuts would be fully realised very rapidly. Hence reductions in what are commonly referred to as the short-lived climate pollutants, or SLCPs, do not only complement CO_2 reductions. By providing a rapid climate success story, they could also help catalyse greater action to reduce CO_2 emissions.

Other drivers of climate change

Many SLCP reductions provide additional benefits through clean air. The second-largest driver of climate change to date is emissions of methane. According to the last assessment by the Intergovernmental Panel on Climate Change, in 2011 methane contributed about 55 to 60 per cent as much warming as CO_2. Besides causing warming, methane enables formation of ground-level ozone, a component of smog that is toxic to both plants and people.

For people, the most recent analysis by my research group finds that current elevated ozone levels lead to about one million premature deaths worldwide each year. For plants, earlier studies have shown that application of current technology to limit methane emissions – especially leakage from the fossil-fuel sector and emissions from municipal waste – could lead to increases in staple crop yields of about 50 million tons per year. Hence methane reductions not only reduce warming, but lead to enormous benefits for public health, and large, readily quantifiable benefits for agriculture and forestry. Most of these methane reduction measures provide benefits that in fact greatly outweigh their costs. Worryingly, methane concentrations in the atmosphere have increased rapidly during the past several years, even when CO_2 emissions have not, with the rise largely attributed to increased use of natural gas (which is primarily made up of methane).

Current climate accounting systems are based on long-term climate impacts alone, thus undervaluing the near-term climate and health benefits of methane reduction. This may be contributing to the world's poor record in controlling methane.

As well as methane, carbon monoxide and a group of compounds called volatile organic compounds also contribute to ozone in the lower atmosphere, and hence cause both warming and air pollution. These pollutants come from motor vehicles, inefficient burning, and evaporation of hydrocarbon-rich compounds such as solvents, petrol and paints.

Though less important than methane for climate, reductions in those emissions also lead to benefits for the world's climate, public health and ecosystems. Implementation of the Kigali Amendment to the Montreal Protocol, which would keep emissions of the powerful hydrofluorocarbon GHGs from continuing to rise, is another key step to mitigate future non-CO_2 warming.

The last major emitted compound driving warming is black carbon (soot) particles from incomplete combustion. These not only contribute to warming but are also part of the small particulate matter that, when inhaled, penetrates deeply into the body, leading to heart attacks, strokes and respiratory disease. The World Health Organization classifies air pollution (from particulate and from ozone) as the world's leading environmental killer. Hence reductions in black carbon likewise contribute to both climate and health goals.

It is important to keep in mind that in most cases, CO_2 reductions are also good for health as they are accompanied by decreases in co-emitted pollution. However, that type of pollution typically causes cooling, and so masks the full warming caused by GHGs. Hence the net climate impact of reductions of CO_2 is likely to be small in the short term.

▲ **Methane flaring on an exploration rig. Methane is the second-largest driver of warming, and its atmospheric concentrations have been rising, largely due to increasing use of natural gas as a fuel**

This makes it all the more important to place controls on methane, black carbon, carbon monoxide and volatile organic compounds.

Incentivising action

The Paris Agreement recognises that climate change mitigation occurs within the larger development context. Efforts to reduce SLCPs inextricably link climate change mitigation to human and ecosystem health, and therefore with the desire to achieve sustainable development.

The Sustainable Development Goals (SDGs) have 2030 as their target date, well before peak warming will be reached. Though climate change is often (correctly) portrayed as a long-term problem, it is also an issue for the near term. Damages are already upon us, affecting the health and livelihoods of those alive today, especially the poorest, and limiting our ability to meet the SDGs.

Even as we pursue the world's long-term warming target, the rapid increases in temperature that are projected to continue over the next few decades will damage human and natural systems. Some long-term impacts such as sea-level rise and glacier melting are influenced by cumulative warming and are thus sensitive to warming over all timescales. Portions of the polar ice sheets, meanwhile, may already be near irreversible temperature thresholds. Given these challenges, there is a clear need to mitigate climate change in the near term as well as in the long term.

Policymakers must realise that non-CO_2 reductions are a crucial part of mitigating long-term and near-term climate change, and of improving human and ecosystem health. Explicitly accounting for the near-term benefits of reducing SLCPs would help incentivise action. Such accounting would also allow us to examine the pathway to the long-term climate target by quantifying the effects on societal wellbeing of the route taken.

Doing so would require reporting separately the emissions related to each pollutant that affects climate. All countries already disaggregate reporting on their current GHG emissions (but not all SLCPs) as part of their inventories submitted to the UN, but future pledges are combined into a single so-called 'CO_2-equivalent' metric. As the various emissions are not equivalent, given their differing lifetimes and air quality impacts, separately specifying them and including all relevant emissions is key to facilitating pathway analyses. The Climate and Clean Air Coalition, which includes more than 60 nations plus additional non-state partners, has developed tools to allow the impacts along the pathway to the target to be analysed.

Emphasising the impact of emissions pledges on public health and sustainable development, as well as on climate change, could help build support for increasingly ambitious pledges. It would demonstrate to policymakers and citizens the local, near-term benefits they would reap in addition to the long-term worldwide climate benefits. ●

Where next for NDCs?

As countries review their nationally determined contributions ahead of the 2020 stocktake, what chance is there of meeting the 1.5°C target?

© Andrew Merry/Getty Images

◀ Bushfire in Blue Mountains National Park, Australia. Despite suffering the consequences of global warming on many fronts, Australia is one of several countries that is not yet on a downward emissions path

By **Bill Hare**, CEO and co-founder, Climate Analytics

At the centre of the Paris Agreement are national commitments to cut emissions – the so-called nationally determined contributions or NDCs. Yet in Paris in 2015, governments already acknowledged formally that the initial NDCs were far from sufficient to meet the Agreement's long-term temperature goal of holding warming well below 2°C and limiting it to 1.5°C. Collectively, NDCs as they are at present will likely lead to global warming of about 3.2°C above pre-industrial levels by 2100.

Outside of the climate negotiations, the world is dancing a Paris implementation tango. A few countries are stepping forwards, others backwards, in implementing the policy to accelerate the system changes needed to achieve long-term transformation. Current national policies, which in many cases have not yet caught up even to these insufficient NDC ambitions, are projected to result in a warming of about 3.4°C unless action is taken quickly.

On a brighter note, last year was the first time the Climate Action Tracker observed an improvement in climate action globally, and brought its warming estimate down from 3.6°C to 3.4°C – a small but significant improvement, despite some troublemakers rattling the anti-climate science propaganda machine. It also found that if planned but not yet implemented policies are enacted, this would lower the projected warming to about 3.1°C.

Some countries, such as Australia, Turkey, Russia and Saudi Arabia, have yet to get onto a downward emissions path and realise the long-term economic and societal benefits associated with limiting warming to 1.5°C. One such benefit is how accelerated and early climate action will improve energy independence. Almost all countries have between 20 and 80+ times more renewable energy potential than current consumption needs.

In other cases, despite governments continuing to pursue fossil-fuel plans, emissions are continuing to fall because renewable energy has become highly attractive economically. In the US, for instance, fossil fuel-based electricity generation experienced its steepest year-on-year decline since the 2008 financial

Also in this section

crisis, despite the government rolling back on climate policies of the previous administration.

Incentives for action

Realising the sustainable development wins from the deployment of technologies and policies consistent with the 1.5°C limit – such as major health, agriculture and economic benefits from reduced air pollution – proves a powerful incentive for action.

China and India are increasingly acting on this, in particular by reducing coal consumption. Five years ago the idea of either country slowing – or even stopping – coal use was considered an insurmountable hurdle, as coal-fired power plants were thought necessary to satisfy the energy demands of these nations. Yet, recent observations show they are now on the way towards overcoming this challenge. Both countries have recognised the benefits of renewable energy in curbing air pollution and, in the case of India, in providing an unparalleled contribution to achieving universal modern energy access.

The NDCs are intended to be dynamic and regularly updated, with higher ambition to reflect advances in science and implementation experience. Indeed, most countries need to urgently update their NDCs to be in line with the Paris Agreement target. Even without considering the much-needed emission reductions this entails, rapid technology developments in key sectors over recent years make it an economic and political necessity to update NDCs, as their underlying assumptions are outdated already.

One of the key grounds for optimism for seeing stronger climate action in the near future is that renewables are now increasingly competitive and often cheaper than fossil fuels. This has changed drastically within just a decade thanks to the rapid increase in installations, incentivised first by a few governments such as Denmark and Germany. This has led to a virtuous cycle of learning and economic scale effects. The sheer size of photovoltaic production and deployment in China, for example, is now lowering prices globally.

Aside from falling costs, a great advantage for renewables lies in their rapid scalability. Even if only part of a solar or wind farm is installed, each unit generates power, thereby lending flexibility to planning. This also means that overcoming energy poverty in the developing world – a key sustainable development objective – is becoming much easier, faster and cheaper thanks to modern renewable technologies and storage systems.

While NDCs are at the centre of the Paris Agreement, the 'ratchet up' mechanism of the agreement is its heart. Countries will collectively take a look at how they're doing on a five-yearly cycle, called the Global Stocktake. They are required at each step to progressively increase their level of ambition, and the Agreement will stand or fall on whether this happens – along, of course, with countries' commitment to turn ambition into action.

Knowing that the initial NDCs were inadequate, it was decided in Paris that countries would submit upgraded NDCs by 2020. As a vital input to this, the Intergovernmental Panel on Climate Change (IPCC) was asked to prepare a special report by 2018, including on the emission pathways required to meet the 1.5°C target. A process was also established to review the collective effect of NDCs in 2018 and provide a common scientific basis for countries to upgrade their NDCs by 2020.

Initially called the facilitative dialogue, this is now known as the Talanoa Dialogue, and is taking place throughout 2018. It is the first opportunity since 2015 for countries to take a look at how their efforts are stacking up against the Paris Agreement temperature goal. Some countries, such as Argentina, have already increased the targets in their NDCs.

What the science shows is that total greenhouse gas (GHG) emissions need to peak by around 2020 and drop towards zero shortly after mid-century. Energy-related carbon dioxide emissions, the largest source of GHG emissions, must approach zero by 2050. This means that a rapid transformation of the world's energy systems is needed. Fortunately, the scientific community has shown that limiting warming to 1.5°C is possible and can be achieved under a range of different global economic and population assumptions. This will have positive and beneficial effects for sustainable development, but only if the world acts to reduce emissions soon. Increasingly, cheap renewable energy, storage technologies and electric vehicles will play a fundamental role in this transition.

Technology developments in key sectors over recent years make it an economic and political necessity to update NDCs, as their underlying assumptions are outdated

More ambitious NDCs

With new heat records around the world, devastating wildfires, water shortages and, tragically, death, the world is reminded that climate change already affects the living conditions of billions. It also illustrates that we are late in the game and the window for action is narrowing, making a rapid acceleration of action imminent.

The latest science, reviewed in the October 2018 IPCC special report, shows limiting warming to 1.5°C will avoid major climate damages. Even half a degree additional warming will produce a bigger cost than previously estimated.

The adoption of the Paris Agreement was a remarkable achievement. This agreement represents our last best chance to come together and take the essential steps to prevent the worst consequences of climate change. With rapid developments in key sectors over recent years, we have technology on our side. These can serve as a powerful springboard for more ambitious NDCs in 2020. ●

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Winners for the 8th Award (2018)

Creativity Prize

The Prize is awarded to two teams of researchers:

1) Dr. Andre Geim and Dr. Rahul Nair (National Graphene Institute, University of Manchester, UK)
for developing novel graphene oxide membranes that promise to enable energy-efficient and high-volume water filtration and desalination.


Dr. Andre Geim


Dr. Rahul Nair

2) Dr. Günter Blöschl (TU Wien, Austria) and Dr. Murugesu Sivapalan (University of Illinois at Urbana-Champaign, USA)
for developing the new field of Sociohydrology, a ground-breaking paradigm for water management and a new validated approach for studying the dynamic interactions and bi-directional feedbacks between water systems and people.


Dr. Günter Blöschl


Dr. Murugesu Sivapalan

Surface Water Prize

Dr. Wilfried Brutsaert (Cornell University, USA)
for developing, demonstrating, and validating a new theory that can generate unprecedented estimates of evaporation from the natural landscape.


Dr. Wilfried Brutsaert

Groundwater Prize

Dr. Martinus Th. van Genuchten (Federal University of Rio de Janeiro, Brazil)
for the development and application of key theoretical and software tools that describe water flow and contaminant transport in the subsurface.


Dr. Martinus van Genuchten

Alternative Water Resources Prize

Dr. Omar Yaghi (University of California, Berkeley, USA) and Dr. Evelyn Wang (Massachusetts Institute of Technology, USA)
for creating a solar-powered device that uses an innovative porous metal-organic framework (MOF) to capture water from the atmosphere.


Dr. Omar Yaghi


Dr. Evelyn Wang

Water Management and Protection Prize

Dr. Jim W. Hall and Dr. Edoardo Borgomeo (Environmental Change Institute, Oxford University, UK)
for developing and applying a new risk-based framework to assess water security and plan water supply infrastructure in times of climate change.


Dr. Jim W. Hall


Dr. Edoardo Borgomeo

Nominations are open for the 9th Award. Nominations can be made online until 31 December 2019.

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How can trade help?

Trade-related mitigation policies can help tackle climate change. What role can the WTO framework play?

By **Ludivine Tamiotti** and **Daniel Ramos**,
Trade and Environment Division,
World Trade Organization

The World Trade Organization (WTO) agreements provide a legal framework that may be relevant to some of the measures adopted by governments in their efforts against climate change. Increasing global concern about the effects of climate change has led to important developments in national regulatory policies in recent years.

In the Paris Agreement, countries agreed to put forward nationally determined contributions (NDCs) to climate change action. According to synthesis reports by the UN Framework Convention on Climate Change Secretariat on these pledges, over half indicate that parties are considering the use of market-based instruments, while some also include strengthening laws and regulations on climate change.

However, successive reports by UN Environment found that even with full implementation of NDCs, emissions reductions would still fall below what is necessary to achieve agreed targets at lowest cost pathways.

The implementation of NDCs, coupled with the move towards lower-carbon and greener economies, will thus require the adoption of a host of ambitious national climate change mitigation and adaptation policies. Naturally, some of those measures will have an impact on trade or will rely on trade instruments. Carbon taxes, green labels, environmental standards and subsidies for renewable energy production are often cited as examples of trade-related climate action.

WTO rules have an important role to play and can make a positive contribution to climate action by ensuring that trade-related measures are coherent and fit for purpose. This avoids unnecessary tensions and ensures that trade plays its role in the move towards low-carbon economies.

More than 20 years of jurisprudence under the WTO show that trade rules do not prevent environmental action. Rather, they seek to ensure that green measures are not applied arbitrarily and are not used as a disguised restriction on trade – in other words, that protectionism is not introduced through the back door. In fact, it seems clear that protectionism could have a negative effect on environmental objectives, for instance by making environmental technologies more expensive and less accessible.

As Erik Solheim, Executive Director of UN Environment, recently stated in an interview with *Climate Home News*, an increase in protectionism would be "very bad for the environment because you waste resources rather than using them effectively. It will make the spread of environmental technologies less fast. And, of course, it will keep more people in poverty for a longer period of time."

Sustainable development is one of the core principles of the WTO and is enshrined in its founding agreement. Trade, as an 'amplifier', is a critical tool in achieving the objectives of the Paris Agreement. This has been recently addressed in a joint study developed by UN Environment and the WTO as part of their high-level dialogue on trade and environment.

In general terms, with the appropriate supporting policies to correctly reflect the costs of environmental degradation and the benefits of ecosystems protection, trade has a role to play in providing the best, most resource-efficient solutions to developmental and environmental needs. Trade leads to important efficiency gains globally, allowing for better use of natural resources. In that sense, what we need (as pointed out in the joint study) are sound social and environmental policies that "can be used to help shift incentives and redirect resources towards more sustainable and inclusive growth".

A multilateral trading system

In recent years, parties to the Paris Agreement have been working together to lay out the rulebook under which climate action shall be deployed. They have also sought to provide more clarity and guidance to ensure as much consistency and harmonisation as possible.

Specific concerns about the economic impact of climate response measures have been the subject of debate under the forum on response measures, established by the 2011 Durban climate conference. The forum has recently been focusing on two topics: economic diversification and just transition of the workforce. The hope is that such efforts will provide a decisive and more coordinated response to the challenges raised by climate change.

Here, a robust and well-functioning multilateral trading system can also help. The WTO has been serving as a framework through which its members have engaged in a peer review of each other's trade policies, including those aimed at achieving environmental goals. Through this multilateral exercise, WTO members are able to quickly address and voice concerns regarding the impact of trade or trade-related policies on their own economies or on the multilateral trading system as a whole. They are also able to exchange best practices and learn from others' experiences.

Data from WTO's Environmental Database show that a steadily growing percentage of trade measures notified are

▲ **Manufacturing solar panels in Lianyungang, China. Trade disputes are impeding the movement and deployment of environmental technologies**

environment-related, reaching around 16 per cent of all notifications in recent years. From 2009 to 2017, there have been more than 10,000 environmental measures notified to the WTO and 7,000 environmental entries identified in trade policy reviews, a periodic transparency exercise that WTO members are required to undergo. Out of these, more than 3,500 measures and around 70 per cent of reviews have included references to climate-related action.

This huge wealth of information offers a window into how WTO members have been pursuing their environmental objectives through trade policies. It also offers an opportunity for members to gather and discuss particular issues. The WTO provides a number of mechanisms for members to exchange views on how these trade policies might more effectively reach their objectives while also enabling trade to play its role.

For instance, in the Committee on Trade and Environment, WTO members regularly discuss issues such as carbon footprints and labelling, NDCs and potential market access implications.

Finally, the WTO works as a forum in which members exchange views and ultimately negotiate ways to improve their trade relations. Opening up trade can help efforts to mitigate and adapt to climate change, for example by promoting an efficient allocation of the world's natural resources, raising standards of living (and hence the demand for better environmental quality) and improving access to environmental goods and services.

According to a study by the World Bank on trade and climate change, the elimination of both tariff and non-tariff barriers to clean technologies could result in a 13 per cent increase in their trade. This would increase the diffusion of such technologies in developing countries and help decrease greenhouse gas emissions.

In sum, the WTO has played and will continue to play an important role in offering an appropriate forum for these discussions, overseeing the trade-related aspects of the debate and ensuring that members are able to exchange views on how best to guarantee that trade and tackling climate change are mutually supportive.

In the current context of enhanced instability and unilateralism, upholding a strengthened multilateral trading system is part of the efforts to ensure an efficient, coordinated and coherent response to the challenges posed by climate change. ●

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Is carbon pricing working?

The Paris Agreement saw more than 90 countries reference plans to establish a carbon market or pricing mechanism. Are these schemes doing enough, and what can be done to make them more effective?

By **Paula DiPerna**, writer and environmental policy adviser

Most people will not pick up hitchhikers, fearing strangers and disliking freeloaders. But the world economy has not been so cautious. Since the Industrial Revolution, global economic activities have been picking up dangerous freeloading strangers in the form of greenhouse gas emissions (GHGs). These are the hidden hitchhikers that are normal byproducts of fossil-fuel combustion. But while GHGs ride along with economic activity for 'free', the costs to the global environment, public health, food and social security climb inestimably higher.

What is the remedy? A first step to covering these indirect costs is to charge the freeloaders, known as carbon pricing. Nations have tried two major approaches (at least) since 1997 and the Kyoto Protocol. The first is outright carbon taxes levied directly on emitters on a per tonne basis, just like a sales tax is added to a dinner bill. The theory is that taxes will deter emissions. But taxes require massive political commitment and public support. Once set, they are politically hard to raise.

Second, there is cap and trade, which sets up market-based competition among emitters. The theory here is that commercial incentives work more effectively than taxes at stimulating innovation to cut GHGs. Cap and trade requires emitters to go on a 'carbon diet' or annual reduction regime. As with taxes, the cap – the official maximum of allowed emissions – is established by government, and is gradually tightened, allowing fewer and fewer emissions. Emitters receive a set of start-up allowances, either free or via an auction, much like the first deal in a card game. But each year the number of allowances issued is reduced, tightening supply and ratcheting down allowable emissions. All emitters must stay below the cap, and so must constantly scour their operations to achieve more reductions.

Cap and trade works on the supply-and-demand principle: the tighter the supply of allowances, the higher the price. Some emitters may be more energy efficient, and so may have surplus allowances to sell. They may achieve their reduction goals more cost effectively than emitters with older equipment or other technical constraints.

No emitter reduction costs are ever the same: a seller's costs may be $15 per tonne, while a buyer may face $25 per tonne. So they bargain, and sellers make money selling their surplus at any price lower than the buyer's costs. Buyers save the difference between actual cost and purchase price. The premise of cap and trade is that as the overall cap is tightened, the price of buying an allowance will climb. When it rises higher than the cost of reducing emissions, emissions reductions will be incentivised. Pricing these allowances means 'pricing carbon'.

> ***Such pricing systems have a common objective: to illuminate the cost of emissions and to gradually make it more costly to emit than to reduce emissions***

In the end, between the buyers and sellers, the same number of tonnes are reduced. In theory, cap and trade prioritises the least-cost reductions. It gives all emitters time to implement the latest technologies while reducing overall emissions.

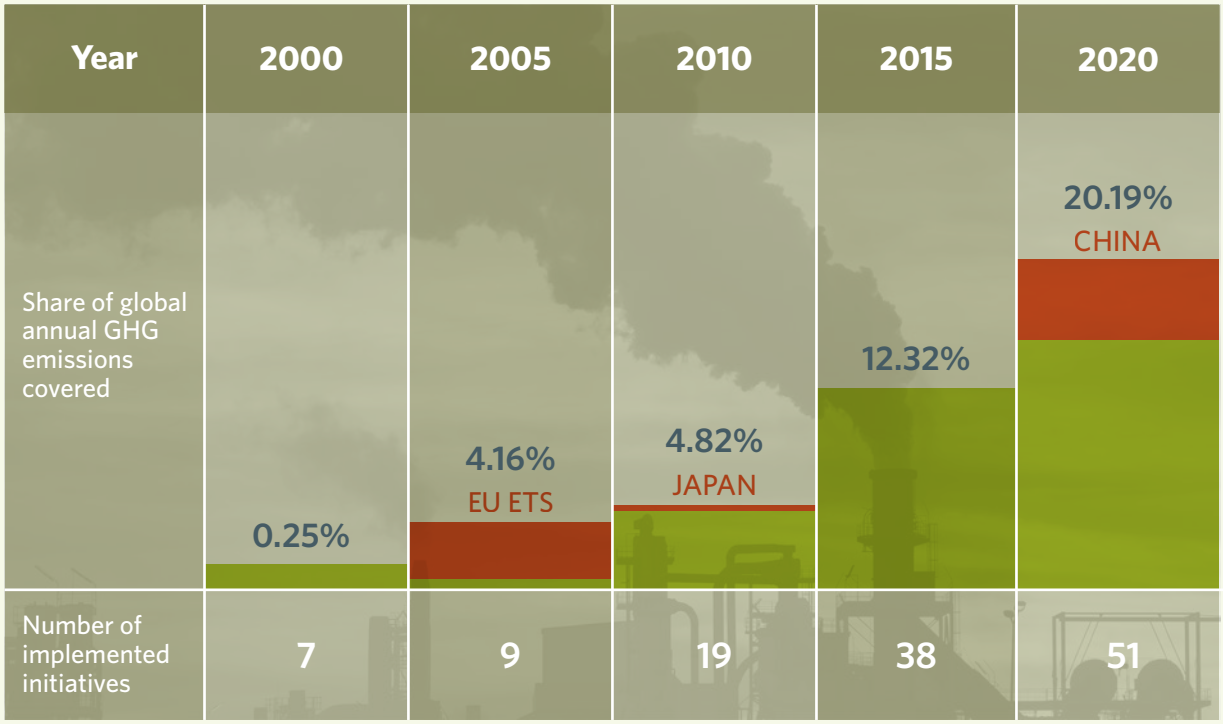
Critics of cap and trade worry that the system lets some emitters off the hook. But as the atmosphere does not care who makes reductions or how, does it matter from a scientific point of view where the obligations fall?

Critics also point out that the system can be gamed if too many allowances are issued, (called 'hot air'). This causes excess supply in the system and means prices remain low. This occurred in the first phases of the EU Emissions Trading System, when prices for allowances collapsed. However, with the 2018 redesign of the system, prices quadrupled from €5 per tonne in May 2017 to over €20 in September 2018. Obviously, no system is perfect or immune to fraud and misrepresentation.

Interestingly, China appears to be opting for a market-based system. In 2015, after establishing various pilot carbon markets around the country, China announced plans for a national system, the rules of which are currently being finalised. In the United States, as national climate change policy disintegrates under the Trump Administration, California and states in the north-east have taken the lead and established state-based cap and trade systems, currently perking along and being refined.

All such pricing systems have a common objective: to illuminate the cost of emissions and to gradually make it more costly to emit than to reduce emissions – not only of carbon dioxide, but also all other major GHGs such as methane and nitrous oxides. Price signals

Growth of regional, national and subnational carbon pricing initiatives, 2000 – 2020



Source: State and Trends of Carbon Pricing 2018, World Bank Group

illuminate possible eventual cost savings from reducing emissions.

As pricing GHGs becomes integral to global economics, it will gradually emerge as fundamental to evaluating corporate near-term performance and strategic management. It will be an important indicator for investors of how well prepared a company may be to face inevitable climate change liabilities.

Facing the inevitable

Recognising this, and despite fragmented public policy, many major companies have come to regard carbon pricing in some form as inevitable. They have begun using an 'internal carbon price' to practise, in effect, the impact of mandatory carbon pricing in business operations. According to the global non-profit and data platform CDP, which began tracking internal carbon pricing in 2013, the number of companies taking this approach jumped from 150 in 2014 to over 1,300 in 2017, including in China, Japan and South Korea. And prices vary greatly, ranging from $4 to $100.

Companies settle on a price based on internal operational costs and price signals from existing markets or tax regimes. Without mandatory structures, companies may still express their internal carbon prices in local currencies for internal planning purposes. But as regulatory regimes emerge worldwide, ultimately those prices will be expressed in international currencies and become fungible, critical to a functioning global carbon market.

As to what carbon price is fair, there is no yardstick. The indirect costs of weather disruption, floods and other catastrophes are only getting more expensive. Individual weather calamities cost billions of dollars and it is estimated that meeting the needs for climate resilience in modernised and updated infrastructure will cost trillions.

A carbon price per tonne is but one element needed to make formerly invisible costs visible so that emitters, and the economy overall, recognise and pay the true costs of emissions. At some stage, though, all costs are passed along to consumers, and consumer tolerance for higher prices for energy and goods remains highly variable.

So, as the world heads into preparations for the post-Paris five-year stocktake in 2020, there is no easy answer on carbon pricing. But, without doubt, invisible hitchhikers can no longer ride for free. ●

Reality check

Countries must report accurately on their progress to cut emissions under the Paris Agreement

By **Yamide Dagnet**, Senior Associate, UNFCCC lead, International Climate Action, World Resources Institute

High-impact weather events continue unabated around the world, hitting the poorest and most vulnerable communities first and hardest. To stand a chance of averting these escalating climate impacts, we need to drastically step up ambition to reduce greenhouse gas (GHG) emissions.

While this is recognised as a global imperative under the Paris Agreement, current national plans – the nationally determined contributions or NDCs – do not do enough to hold global temperature rise to 2°C above pre-industrial levels, let alone the more stringent goal of 1.5°C.

To give the world a fighting chance of averting climate catastrophe, NDCs need to be significantly enhanced by 2020. It is also critical that we have a system in place to check whether countries are on track to meet their individual and collective climate commitments, and whether countries' actions will add up to limit warming to below 2°C. Countries are currently designing such a system, through the negotiations of the implementation guidelines and processes that aim to turn the Paris Agreement into a functioning, effective regime.

The transparency framework

The Paris Agreement established an enhanced transparency framework package. This commits all countries to report on their progress to reduce GHG emissions, build climate resilience, and track the support they provide or receive to transition to a zero-carbon, climate-resilient economy. It also obliges them to get their data and climate plans checked, to assess whether countries are fulfilling their individual and collective commitments. The review process comprises two phases: i) a technical expert review; and ii) a facilitative, multilateral consideration of progress. The review process puts a premium on identifying individual gaps, discrepancies and needs, while enabling countries to pinpoint and share best practices and lessons learnt with technical reviewers. It allows countries to identify both opportunities and ways to overcome barriers, improving data over time.

While the Paris Agreement tells countries what to do, it does not say how. In December 2016, at COP22 in Marrakesh, Morocco, countries set December 2018 – the date of COP24 in Katowice, Poland – as the deadline for adopting the implementation guidelines, also known as the 'rulebook'. These rules of the game are essential to make the Paris Agreement operational. Failure to get these guidelines right, so that they are clear, robust and enabling, could mean that the Agreement does not become the regime we envisioned and celebrated back in December 2015.

The transparency rules and processes are critical to ensure that governments implement their national plans, and to trigger more robust climate risk management and resilience strategies from investors. The rules will not only hold governments accountable for their commitments, but will also build confidence between all stakeholders involved in the implementation of Paris: to 'walk the talk' and turn commitments into meaningful actions and outcomes, at an accelerated pace. This is why the Paris Agreement gives a special focus to transparency.

But the nature of the Agreement – country-driven, managerial and norm-building – affects the design of the transparency framework, and its ability to facilitate the aggregation of countries' efforts and prevent 'free riding'.

Designing the framework

The bottom-up nature of the Paris Agreement, embodied by the NDCs, tends to emphasise the national economic, social and institutional circumstances that affect the implementation and possible enhancement of country commitments. This privileges flexibility and national sovereignty. Yet this country-driven approach sits alongside some common sets of guidelines and legally binding rules guiding countries' efforts (yet to be adopted), collective quantitative goals (limiting temperature rise), qualitative objectives (resilience and alignment of financial flows), and direction of travel.

Because the Paris Agreement recognises that countries are at different stages of development, and therefore have different capabilities to meet their requirements, the enhanced transparency framework provides some flexibility for developing countries. However, this flexibility should be bounded, so that the information countries provide can be aggregated to allow an accurate assessment of collective efforts. The review process needs to be designed and to perform in such a way that it drives timely provision of information and improvement of data over time. It needs to effectively inform the domestic policy cycle as well as national and international decision-making.

The outputs of the transparency framework will include various reports: national biennial transparency reports, review reports, and also summary reports from the UN Framework Convention on Climate Change Secretariat, which could be syntheses of the national reports.

These output materials should provide relevant information on each country's individual efforts, as well as facilitate aggregation of information to assess collective efforts. This will include evaluating progress toward the long-term goals under

▲ **Informal consultations on the Global Stocktake at COP23. The success of the Paris Agreement will depend on adopting a clear and robust 'rulebook' at COP24**

the Global Stocktake (the mechanism established under the Paris Agreement to take stock of collective progress).

Furthermore, the managerial nature of the Paris Agreement advocates a facilitative approach that identifies problems and seeks to troubleshoot (rather than imposes penalties and sanctions). This is based on the assumption that failure to comply would be the result of capacity constraints rather than countries' disregard for adopted rules and commitments.

The technical expert review team will likely be the first to be exposed to cases of non-compliance with the reporting and accounting requirements. If countries agree, they could refer such cases to the committee established under the Paris Agreement to facilitate implementation and promote compliance. Such a process could for instance assess eligibility requirements related to participation in, and use of, market mechanisms. The Paris Agreement allows countries to voluntarily cooperate in implementing their climate actions and commitments by using such mechanisms.

The aim here is to increase their efficiency when it comes to both implementing their commitments and also increasing their ambition. However, to enable countries to do this in a way that preserves environmental integrity, we will need robust transparency and accounting rules. These must be supported by a sound and effective national and international governance system. All of this will be required to ensure that the results of such cooperation (especially if it involves the transfer of mitigation outcomes) avoid double counting. The verification undertaken by the teams of expert reviewers will be crucial.

In addition, the facilitative multilateral consideration of progress (the second phase of the review processes under the enhanced transparency framework) could help identify systemic issues. This could be considered further by the committee established to facilitate implementation and promote compliance, and be highlighted in annual or special reports.

Transparency and accountability are more than technical buzzwords. They are the backbone of the Paris Agreement, playing a critical role in strengthening trust among countries and wider stakeholders. They also foster better cooperation, necessary if we are to transition to a prosperous and fair low-carbon and climate-resilient economy.

The managerial and enabling dimension of the transparency framework is an essential feature of the Paris Agreement. The framework's reporting and review process (including the way it is linked to the Global Stocktake and compliance mechanism) is expected to help identify capacity gaps and other resource constraints that countries may face.

Such a process should provide countries with space and assistance to identify ways to adapt – by building more robust and responsive domestic measurement and tracking systems – and strengthen relevant national and international institutions, and their associated decision-making processes. ●

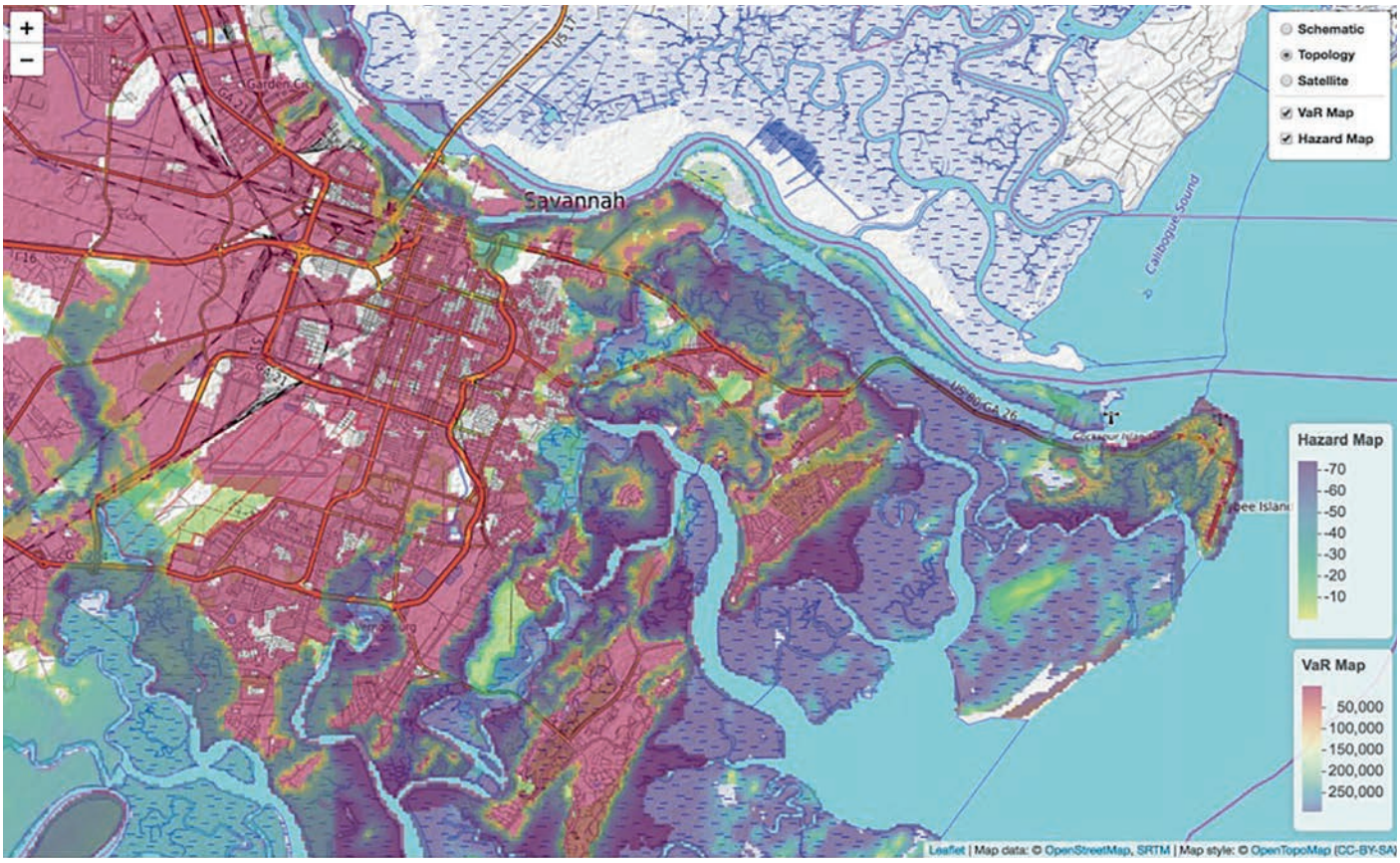
Data-driven solutions

In an age with more climate data than ever before, how can we harness it to drive genuinely evidence-based climate action?

By **Auroop R. Ganguly**, **Evan Kodra**, **Udit Bhatia**, **Mary Elizabeth Warner**, **Kate Duffy**, **Arindam Banerjee** and **Sangram Ganguly**

The fourth and fifth assessment reports by the Intergovernmental Panel on Climate Change have declared global warming to be "unequivocal" and anthropogenic drivers to be "extremely likely" as the dominant cause. These conclusions, expressed in cautious scientific language governed by strict criteria, need to serve as a clarion call for action – from urban communities to world bodies – to

Figure 1. Blended hazard and value-at-risk map of Savannah, GA, USA



prepare for what is likely, and to prevent the worst from happening.

Climate adaptation and mitigation have been respectively called "managing the unavoidable" and "avoiding the unmanageable". While individuals, communities and nations may understand that there are inherent costs to both climate action and inaction, developing a comprehensive, evidence-based, scientifically credible and risk-informed action framework is not straightforward.

National and global climate mitigation policies include investments in renewable energy, carbon capture and storage solutions, divestments in fossil fuels, and environmental and land-use regulations. The will of nations to act may depend on perceptions of climate impacts and vulnerability on their respective societies and institutions – and on the challenges in adaptation.

Impacted sectors include natural resources (such as food, energy, water, ecosystems), hazards and humanitarian aid (for example, critical infrastructures resilience), as well as population growth and movement (such as environmental refugees).

However, while predictive insights from climate models and data are usually more credible at aggregate scales in space and time, climate action may be better suited at the local scale such as within urban communities. Urbanisation contributes significantly to emissions and land-use change, and hence to climate change, while urban areas are significantly impacted by climate change.

Communities in urban, peri-urban or rural regions need to understand, adapt to and mitigate risk elements. These include global-scale and locally exacerbated hazards (such as global warming and urban heatwaves), vulnerabilities of infrastructures and lifelines (including natural-built and grey–green infrastructures), as well as exposure of economic assets, ecosystem services and human populations.

Data-driven understanding and predictive insights can improve risk-informed adaptation and mitigation in three ways: (i) through improved understanding of earth

◀ **Hurricane Florence approaching the east coast of the USA, as viewed from the International Space Station. Although climate is a 'big data' science, only a small amount of the data has been systematically analysed**

▲ **Figure 1. Here we show an example of risk assessment by our startup, risQ, which blends diverse concepts and disparate data sources. Coastal floods are modelled for multiple return periods under sea-level rise. Inundation depths and extents are intersected with geospatial layers, including property value and industrial workforce concentrations, over a municipality. This allows for estimating the municipal tax revenue at risk from climate change. Analysis on comparative tax dollars at risk under climate change could help bond investors and financial rating agencies better quantify the true municipal and state credit risk. This map exemplifies modelled 10-year tidal flood depth and extent ('hazard map') under current sea-level conditions in Savannah, GA, overlaid with a workforce density index ('value-at-risk map') to help stakeholders estimate industrial output risk**

systems science and engineering, translating to the probabilities and attributes of stresses and shocks; (ii) through risk frameworks, including risk assessments, which consider threat, vulnerability and exposure, emergency management (including preparedness and recovery), as well as time-phased and flexible adaptation strategies; and (iii) mitigation at multiple scales, from global and national to urban and community.

Climate model simulations and remotely sensed observations already exceed petabyte scales (one petabyte equals 1,000 terabytes) and are expected to reach a few hundred petabytes within the next couple of decades. But even though climate is now a 'big data' science, only a small fraction of the available data has been systematically analysed. Furthermore, even as 'big models' are increasing in space-time resolutions and complexity, this is not necessarily leading to more certainty in stakeholder-relevant insights.

Machine learning

So, a group of climate modellers have resorted to machine learning (ML) – a subfield of artificial intelligence – to estimate parameters for high-resolution atmospheric processes such as convection. Others have explored ML-based post-processing of model simulations, often guided by physics to obtain finer-scale projections. Beyond atmospheric science, terrestrial ecology has benefited through ML through the creation of a global plant attribute database, which in turn used an advanced data-driven parameter estimation method within numerical models.

Despite these efforts, our lack of understanding of complex climate processes and feedback, as well as sources of irreducible uncertainty, may persist.

First, greenhouse gas emissions and land-use change scenarios that drive the models are not precise predictions with probabilities, but are what-if scenarios.

Second, gaps in our knowledge of the climate system may not be easily plugged. Uncertainties result from variabilities across model simulations as well as their lack of correspondence (when models are hindcast into the past) with observations.

Third, inherent variability exists in the climate system, including extreme sensitivity to initial conditions, which contributes to the irreducible component of uncertainty.

These three components contribute to the overall uncertainty. In the crucial 0–30 year near term, the projected climate change signal may be within the bounds of this overall uncertainty, which may in turn be dominated by the inherent variability.

Climate challenges go beyond 'big' models and big data. Indeed, climate science is also dominated by what may be viewed as 'small data' challenges. Historical records from the data-poor eras of earth science are sparse,

▼ **Figure 2. In 2012, Hurricane Sandy inundated New York City, causing billions of dollars in damage and costing the Metropolitan Transportation Authority (MTA) an estimated $124 million in lost revenue. Using a system-recovery modelling approach, the MTA could have hypothetically saved an estimated $56 million dollars and restored service in less time by strategically prioritising station recovery. Left top: percentage of service restored is shown step-by-step as stations are recovered in sequence. The yellow line is based on the actual sequence of recovery, and the blue is driven by the recovery model. Left bottom: same but for estimated MTA revenue, as inferred using historical MTA data. Middle and right: a snapshot of the modeled MTA recovery mid-process, for the model and the actual historical recovery, respectively**

Figure 2. Recovery model for the New York City metro after Hurricane Sandy

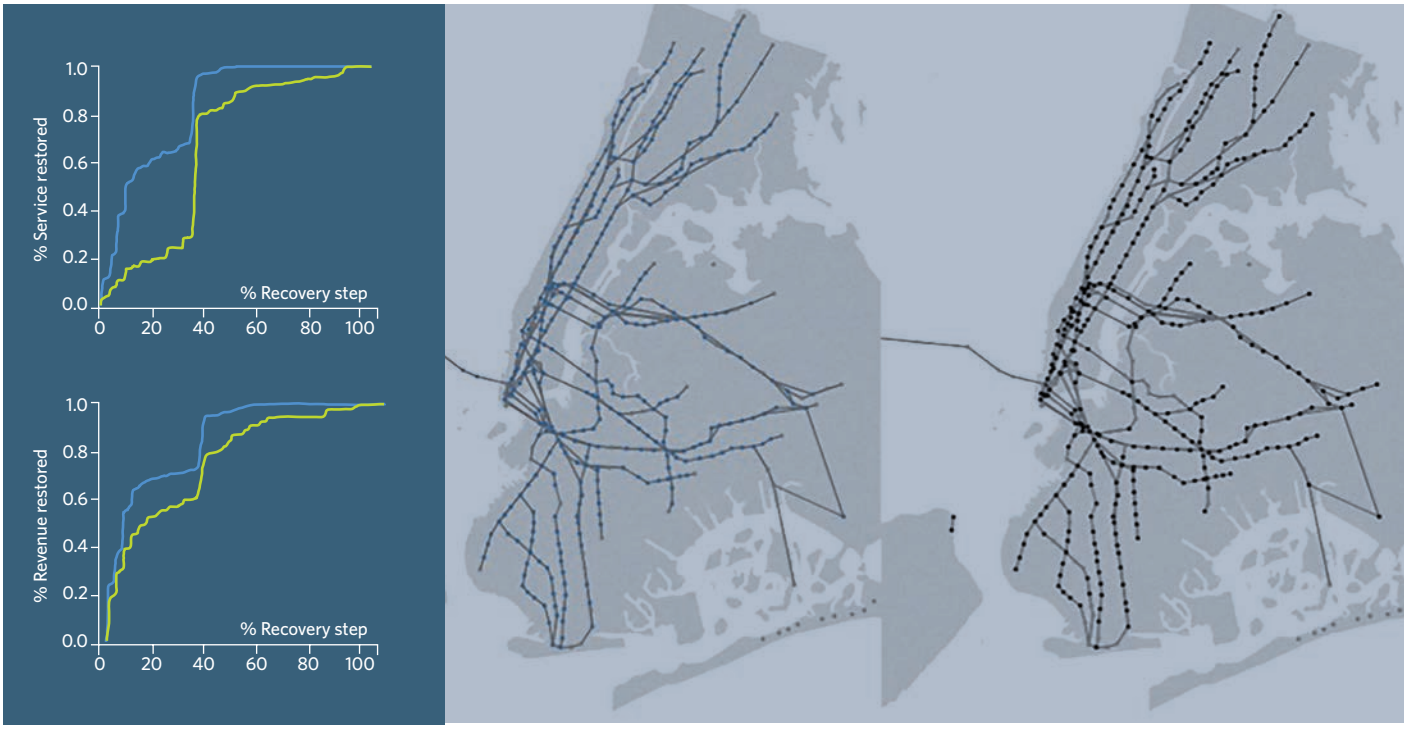
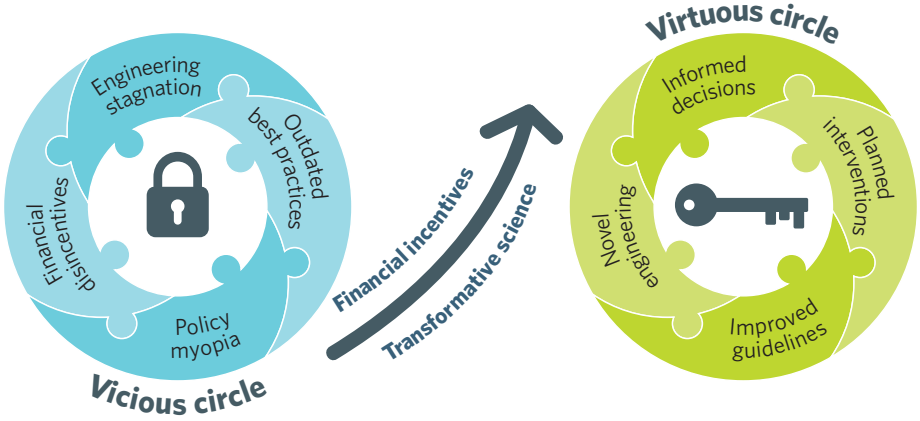


Figure 3. Breaking the maladaptation cycle



making historical reconstructions difficult to validate. Climate signals exhibit temporal fluctuations ranging from sub-seasonal to multi-decadal and even longer time scales (low-frequency variability).

The lack of historical data makes it challenging to understand changes or delineate signals from longer-term variations, although reconstructions based on models, instrumented records (even if relatively sparse), and proxy data (such as tree rings, fossils and ice cores) help to partially address aspects of the information gap.

Furthermore, climate data challenges are made worse by complex dependence. Tobler's first law of geography states that "everything is related to everything else, but near things are more related than distant things". While climate data exhibit this property in space and in time, long-range spatial dependence and persistence in time are also common.

Finally, climate change is not just a matter of mean change (for example, global warming) but also about changes in the patterns of extremes such as heatwaves, cold snaps, heavy rain, droughts, floods and hurricanes. Weather extremes turn to catastrophic disasters when hazards (e.g., a hurricane) are aligned with infrastructural (e.g., an inadequately designed dam or levee) and societal (e.g., economic disparity) vulnerability, exposure of people and assets (e.g., businesses and natural resources), as well as lack of emergency management plans. The relative rarity of such extremes adds to the 'small data' challenge and brings to the fore the need to manage, assimilate, analyse and interpret heterogeneous information.

Nonetheless, extracting predictive insights about the statistics of change and extremes is possible based on specialised data-driven methods such as extreme value theory, network science and signal processing. Thus, our research has examined complex dependence patterns, low-frequency variability in climate (including for extremes) and developed predictive insights. We have studied heatwaves and cold snaps, heavy precipitation, high winds, droughts and urban climate extremes.

Our work on droughts and heavy precipitation has examined long-memory processes and teleconnections. We have discussed deep uncertainty (i.e., where probabilities cannot be easily assigned) and non-stationarity (i.e., significant and fundamental change) in climate and hydrology, as well as in climate adaptation and resilient engineering, and the possibility of blending physics and data sciences to address these challenges. Figure 1 illustrates how simulations and observations from earth system science combined with ancillary information may help generate predictive insights in climate and develop risk assessments.

Attribution studies, where change patterns are related to possible causes, are typically based on observations and model simulations. This is one area where we believe the climate science community can benefit significantly by interacting with a wider group of interdisciplinary scientists.

Stakeholders such as the US Department of Defense indicate that climate change is a threat multiplier across many sectors, and hence adaptation and mitigation are urgent and necessary. Data challenges in adaptation and mitigation sectors are diverse and disparate – ranging from big data to small data, information gaps and confidentiality issues – and are exacerbated by gaps in understanding processes and the possibility of cascading failures.

Data-driven methods, data-informed, process-based approaches and physics-informed, data-science methods have all been found to be useful. Robust decisions and flexible-planning pathways have been suggested. We have examined coastal processes, water-energy nexus, transportation networks, public health and urban heatwaves, and regulatory principles. Figure 2, for example, shows how recovery strategies designed in anticipation of weather extremes can help save lives and money.

Future work may need to creatively leverage data from the public domains or from well-crafted simulations and testbeds. It may also incorporate confidential data that could still be used either through anonymisation or by following privacy regulations. The state of the art in critical infrastructures resilience offers specific examples.

Finally, the importance of economic incentives to overcome hurdles to best practice or to engineering innovation, as well as to policy myopia, cannot be overemphasised. These in turn may require analysis of financial, demographic and socio-economic data. Figure 3 suggests how a vicious cycle of maladaptation may be transformed to a virtuous cycle through improved incentives and innovations. ●

Note: AR Ganguly, Bhatia, Warner and Duffy are at Sustainability and Data Sciences Laboratory (SDS Lab) of Northeastern University (NU) in Boston, MA, USA; Kodra is at the startup risQ (spinout of the SDS Lab) in Cambridge, MA; Banerjee is at the University of Minnesota (computer science) in Twin Cities, MN; S Ganguly is with the NASA Ames Research Center at Moffett Field, CA. An accompanying list of references is available online at www.climate2020.org.uk

Suing for the future

Can the courts force governments to act on climate change?

By **David L. Faigman**, Chancellor and Dean and John F. Digardi Distinguished Professor of Law, University of California Hastings College of the Law

A fundamental, perhaps *the* fundamental, challenge of our time is climate change. Along with nuclear proliferation and financial stability, it is an issue of global proportions and, in the end, requires global solutions. Indeed, as evidenced by the Paris Agreement, it is a problem that nearly every nation in the world understands and is committed to confronting.

Unfortunately, the one nation that today fails to appreciate the perils of climate change is the United States, one of the world's foremost contributors to the problem. If only the United States could be moved from its lethargy, perhaps the worst consequences of global climate change could be avoided.

The United States is the most powerful nation on Earth, both economically and militarily. Currently, however, two out of three branches of the United States government – the legislature and executive – are controlled by politicians that are in abject denial of the pending global climate crisis. This raises the question of whether the third branch of government, the judiciary, might yet step in and mandate action by the other two branches.

The cornerstone of the American constitutional system is the principle of checks and balances. In *The Federalist*, James Madison famously observed: "If men were angels, no government would be necessary. If angels were to govern men, neither external nor internal controls on government would be necessary." Since men are not angels – and our governors surely are not – "the great difficulty lies in this: you must first enable the government to control the governed; and in the next place oblige it to control itself."

In that same monumental work, Alexander Hamilton referred to the judiciary as "the least dangerous branch," because it had recourse to neither the purse nor the sword. Given the political realities of the United States today, it is that least dangerous branch that is needed to address global climate change, surely one of the most dangerous threats facing humankind.

A judicial check on legislative and executive negligence

The founders of the American Constitution sought to embed checks and balances through two basic divisions of power. First, they divided sovereign authority between the states and the federal government, a principle known as 'federalism'. The second involved the further division of the federal government into three branches – the legislature, executive and judiciary – a principle known as 'separation of powers'.

Although both of these divisions of authority are relevant to efforts to make the US more responsive to combating climate change, federalism is less controversial as a matter of American history and tradition. States have always taken a leading role in responding to matters of sovereignty, and there is a long tradition of state/federal competition, combat and collaboration.

What is somewhat more controversial, especially in regard to problems of global reach, is eliciting the judiciary's support to demand that the more political branches of the federal government live up to their responsibilities. In short, the great question is whether litigation might provide the impetus, indeed the demand, for the US to rejoin the world community's efforts to save the globe.

Litigation as a route to broader change

Under the Constitution, courts are limited to deciding concrete cases arising under the laws of the United States. Courts are not legislatures and thus have no authority to regulate the polluters that contribute to the problem. Hence, it might indeed seem initially inappropriate for the courts to assume responsibility for what could be described as a 'political' issue, one necessitating a legislative or executive response.

But, in fact, American courts have a long history of considering, and seeking to remedy, broad and systemic wrongs under their constitutional authority. Perhaps the best example of this is the case of *Brown v. Board of Education*. In *Brown*, the plaintiffs claimed that segregated schools violated the Fourteenth Amendment's guarantee of the equal protection of the laws. The Court agreed that segregation was unconstitutional and ordered schools to desegregate "with all deliberate speed".

Although the *Brown* litigation ostensibly involved only five jurisdictions and their respective schools, the finding was broadly understood as applying to segregated schools nationwide. Indeed, the *Brown* ruling that school segregation was unconstitutional was subsequently, and largely summarily, extended to public facilities generally, including bathrooms, water fountains, pools and so forth.

The current signature case involving litigation over global climate change is *Juliana, et al. v. United States, et al*. The plaintiffs in the case are a relatively small number of minors who claim that global climate change has caused them substantial ongoing injuries and poses a significant risk of future injuries. Moreover, the *Juliana* plaintiffs argue, among other things, that the United States government has a constitutional obligation under the Due Process Clause of the Fifth Amendment to ensure a liveable and safe environment. This duty arises, in part, because the government has assumed stewardship responsibilities, through statutes and regulations, over the

▲ The plaintiffs in *Juliana, et al. v. United States, et al.*, the current signature case involving litigation over global climate change

environment. In effect, the plaintiffs claim that the federal government has been negligent in carrying out its responsibilities to safeguard the lands, sea and air of the United States from the deleterious consequences of carbon dioxide emissions.

Juliana presents a number of interesting parallels to the *Brown* litigation. Like the *Brown* plaintiffs, the *Juliana* plaintiffs are members of a class that are injured by actions or omissions of the controlling authorities. In both cases, the plaintiffs did not seek monetary damages, but instead seek injunctive relief to remedy an ongoing constitutional violation. In *Brown*, the court did not specify how states should go about desegregating their schools, only that they must do so. The form desegregation should take was for states to determine. Indeed, the issue continues to be a source of litigation to this day.

Similarly, the *Juliana* plaintiffs seek a court order specifying a goal for carbon reduction, but would leave the how to the government to ascertain (hopefully, if the *Juliana* plaintiffs are successful, it will not take 50 years to resolve the details of the remedy).

There is yet another intriguing similarity between *Brown* and *Juliana*. The United States in *Juliana* has defended its position by, on the one hand, accepting the factual proposition that human-made climate change is scientifically grounded. On the other hand, it is arguing that the plaintiffs cannot show any particular injury from that consequence.

In legal-speak, the government asserts that the plaintiffs lack standing to bring their lawsuit and, if they do have standing, that they cannot prove that climate change has caused individual harms. Specifically, the government argues that while the number and intensity of storms, or the number and intensity of wildfires, have increased with climate change, the plaintiffs cannot prove that any one super storm, or any one wildfire, was specifically caused by climate change.

The government, however, is fundamentally mistaken in its strategy. Plaintiffs need not prove individual causation. The science proving general causation is sufficient in this constitutional claim. In *Brown*, for instance, although the plaintiffs introduced social science research indicating the deleterious effects of segregated schools on black children, the Supreme Court did not demand proof that the individual named plaintiffs suffered any of the deleterious effects of segregation. It was sufficient that they were in the class of individuals at risk for such demonstrated effects.

In terms of asserting a constitutional right, the *Juliana* plaintiffs are suffering the real effects of, and confront the continuing substantial risks associated with, global climate change. If there is indeed a fundamental right under the Fifth Amendment to a liveable and sustainable environment, the *Juliana* plaintiffs should prevail in their lawsuit.

An opportunity to be seized

The cornerstone principle of American constitutional democracy is that of checks and balances. A key manifestation of that principle is the separation of powers between the legislature, executive and judiciary. When one or another of the branches has failed to fulfil its constitutional obligations, it falls to the other branches to balance that failure.

Today, the two more political branches – the legislature and the executive – have failed in their constitutional responsibilities to adequately steward the environment. The judiciary now has the opportunity and the power to remedy those failures. It is time for the courts to fulfil their constitutional role. ●

Protecting and empowering children

Children are the most vulnerable in every crisis, and climate change is no exception. But children deserve more than protection – they need tools to be the agents of change

◀ Children collecting drinking water from a public pump in Sana'a, Yemen, a country where the impacts of climate change have combined with conflict

By **Gautam Narasimhan**, Senior Adviser – Climate, Energy and Environment, UNICEF, and **Meghna Das**, Senior Programme Specialist – Sustainability, UNICEF UK

Children are the most affected by the rising number of climate-influenced humanitarian disasters such as hurricanes, droughts and floods. They suffer immediately and also face longer-term impacts on their opportunities and livelihoods. Rising temperatures increase incidences of vector-borne and water-borne diseases while air pollution leads to dangerous respiratory and health conditions, which hit children the hardest.

Extreme weather events destroy the clinics and schools that provide the healthcare and education they need to better cope with a changing climate. Changing temperature and rainfall patterns, meanwhile, degrade food production, causing hunger and malnutrition, and force people to migrate – further disrupting the lives and futures of children. As climate change exacerbates the root causes of instability and conflict, children will be even more vulnerable to violence, exploitation and abuse.

Climate change also exacerbates inequity, disproportionately affecting the poorest, most vulnerable and marginalised, deepening existing inequities and perpetuating them over generations. Children and families who are already disadvantaged by poverty, and therefore have the fewest resources for coping with its impacts, are likely to face some of the most immediate dangers of climate change. For example, flood and drought zones often overlap with areas of high poverty and low access to essential services such as water and sanitation.

And climate change is a child-rights issue. It threatens children's most basic rights: to health, access to food, water, clean air, education and protection – even their survival. But children and young people are not central to the global climate dialogue. A child-rights approach is often missing in many policies.

A clean, safe environment for every child

UNICEF recognises that effective responses to environmental degradation (including climate change) are central to its mission to realise the rights of every child – especially the most vulnerable. This recognition is guided by the UN Convention on the Rights of the Child (UNCRC), the Sustainable Development Goals and the Sendai Framework for Disaster Risk Reduction (2015–2030). To that effect, in its new Strategic Plan (2018–2021), UNICEF has committed itself to the

Also in this section

goal that 'every child lives in a clean and safe environment'. UNICEF's focus has been prioritising children and their rights in climate action. Important areas of our climate change work include:

1. Advocacy and accountability: being a strong advocate for the rights, voices and vulnerabilities of children to be central to climate and environmental planning – locally, nationally and globally.
UNICEF uses its influence, reach and expertise (including generating evidence) in over 190 countries to support governments' efforts to reach their commitments; to hold them accountable for doing so; to help develop more ambitious programmes that protect children from the impacts of climate change and environmental degradation; and to strengthen engagement of young people in actions related to climate change.

- In 2015, UNICEF, working with the UK National Committee for UNICEF, was instrumental in the inclusion of children's rights in the Paris Agreement. This is a significant advance: it is the first global environmental treaty to recognise the relevance of human rights, including explicit recognition of children's rights, in the context of climate action.
- Article 24 under the UNCRC recognises the right of children to enjoy the highest attainable standard of health and environment. In 2016, UNICEF UK provided a written submission to the Committee on the Rights of the Child for the Day of General Discussion on 'Children's Rights and the Environment'. The submission focused on the challenges that children face in relation to climate change, air pollution and water security. It also recommended that the UNCRC be considered in climate-related policies, action, investments and dialogue.
- UNICEF promotes the role of children and young people as agents and advocates of change. Children are not only victims of climate change – they also have a critical role to play in building their own and their communities' resilience to climate shocks and stresses. They are also key to promoting and adopting more sustainable low-carbon lifestyles – both

- More than half a billion children live in extremely high flood-risk zones and more than 160 million live in high or extremely high drought-risk zones (see the UNICEF report, *Unless We Act Now*).
- Approximately 300 million children live in areas with extremely toxic levels of outdoor air pollution, with increasing evidence that air pollution is affecting children's cognitive development (see the UNICEF report, *Clear the Air for Children*).
- Some 600 million children, or one in four worldwide, will be living in areas with extremely limited water resources by 2040 (see the UNICEF report, *Thirsting for a Future*).

Solar-powered water in Malawi

Solar-powered water systems are helping children in remote off-grid communities access clean water in their villages, health centres, schools and homes. Yesaya's life has changed for the better after a solar-powered water pump was installed near his school by UNICEF Malawi. Before this piped water, the students used to travel long distances to the nearest available water source. "This was also very unhygienic as livestock used to drink from the same water source," Yesaya says. "My four siblings and I used to suffer from diarrhoea and could not attend classes regularly. With clean water available near our school, we are now able to attend class every day."

Countries like Malawi have heavy dependence on natural resources and rains. This means they are particularly vulnerable to the effects of climate change, forcing children to travel long distances to reach the only available water source. Access to clean water becomes crucial for survival in the dry season, and the non-availability of grid electricity for pumping water in most remote areas adds to the burden. A solar-powered water system can transform water access for children and families in these areas. By using solar energy, the systems use cleaner fuel and can pump treated water from a borehole to different communities, schools and health centres. This provides more than just clean water: it also improves health and education outcomes for children.

▲ Yesaya drinks water from a tap at his school, connected to a solar-powered water pump

Empowering children through disaster planning

Climate-related disasters are on the rise and are responsible for untimely disruption and deaths. Tragically, children make up more than half of those affected, and when a disaster strikes, children are the hardest hit. It is vital that children have the knowledge and life-saving skills that can support their survival and development in the event of a disaster. Recognising this, country offices like UNICEF Philippines are working to promote disaster risk reduction and climate adaptation programmes for the most vulnerable.

The participatory 3D map is a joint project between UNICEF Philippines, the Center for Disaster Preparedness and the University of the Philippines Department of Geography. It can tell people in a village about the risks, vulnerabilities and capacities of their village to help them with disaster planning. If children are empowered, they need not be victims, but can be agents of change too.

▲ Using participatory 3D mapping, Lyn Lyn, 10, explains the hazards and vulnerabilities in her village

now and as future decision-makers, teachers and parents. It is vital that they are empowered with the education, skills and means to advocate for, and effect, change. In Zambia, for example, child-led advocacy programme Unite4Climate empowers 11- to 17-year-olds to become climate ambassadors. More than 1,000 ambassadors have reached over one million community members through peer-to-peer outreach and education, and by implementing low-cost community projects on climate change adaptation and mitigation (see UNICEF UK's report *Children and the Changing Climate*).

2. Providing children and communities with the tools to cope with the reality of climate change, both by reducing the impacts on children and by increasing their opportunities to participate in the green economy.
This includes strengthening early-warning systems for extreme climate events, providing emergency humanitarian support when disasters do occur, and bridging the divide between emergency operations and resilient development.

Examples include climate-resilient WASH (water, sanitation and hygiene) infrastructure such as: remote sensing to identify water sources; aquifer-recharge systems that capture water during the monsoon season, purify it and store it underground for use when water is scarce; improved water management systems; cyclone and flood-proof schools; climate and environment education and awareness-raising; and youth-led energy innovation hubs (providing skills or training for green jobs) through youth initiatives such as the recently launched Generation Unlimited.

This also includes strengthening air quality monitoring systems to draw attention to air pollution and to design solutions that reduce children's exposure. For children, again, the stakes are higher, as scientists increasingly recognise that the effects of air pollution are not just short term.

UNICEF also promotes the use of sustainable energy, both as a means to reduce emissions and also to provide more climate-resilient service delivery. Examples include electrification of health facilities and schools with renewable energy solutions like solar systems for cold chain equipment; lighting, cooling and heating in schools; and support for use of fuel-efficient cook stoves in households to reduce air pollution and emissions.

3. Incorporating sustainability into UNICEF operations and programmes.
UNICEF believes in walking the talk by working continuously to incorporate sustainability into its own operations. These include using energy more efficiently, using renewables and disaster-resilient construction, and monitoring and continuously improving its own emissions. UNICEF is taking all these steps to support tomorrow's generation – today's children – to continue the fight against one of the greatest threats to their wellbeing and basic rights. ●

Change in the Delta

In Viet Nam's Mekong Delta, climate change effects such as saltwater intrusion are increasingly devastating crops and livelihoods. To help people adapt, we need innovative, collaborative action between communities, governments and agencies

By **Jenty Kirsch-Wood**, Senior Technical Advisor on Climate Change Adaptation and Resilience, UNDP Viet Nam, and **Phan Huong Giang**, Media and Communications Analyst, UNDP Viet Nam

Viet Nam is extremely vulnerable to climate change impacts. Over recent years, the southeast Asian nation has experienced more irregular and intense climate variability and sea-level rise, manifesting in more unpredictable storms, flooding, drought and saline intrusion. Already-vulnerable groups such as the poor, female-headed households, people with disabilities and the elderly are more heavily affected than others.

Ms Nguyen Thi Nuong is an elderly widow living in the Phu Ngai commune of Ba Tri, Ben Tre province, in the Mekong Delta region of Viet Nam. The Delta is known as the land of white rice and clear water, and is also the country's largest rice, fruit and fisheries producer.

But Ben Tre is also seeing the impacts of climate change. In 2016, the province was hit by a severe drought and saline intrusion. More than 19,500 hectares of agricultural land were seriously affected. Of 164 communes, 160 lacked fresh water. The river water became four times more salty than normal and canals dried up, causing tremendous difficulties for local residents.

"After my husband died two years ago we fell on hard times. But our situation got worse with the drought and saline intrusion in 2016. All our rice and vegetables died. We had to take out several loans for our farm and we lost everything," Ms Nuong shared, remembering the country's worst drought in more than 60 years. This is not the first time she has been hit by natural disaster. Now in poor health, she is still recovering from the collapse of her house during Typhoon Durian in 2006.

Before the drought of 2016, her family owned nearly half a hectare of land for cultivation. But to cover the cost of bank loans of over 100 million VND ($4,250), she was forced to sell more than two thirds of the land. She now rents it back for 30 million VND a year.

"I had taken out loans to build a latrine, and for land and fertiliser. But I had no idea that the saline intrusion would come so early and seriously," she said. "The dry land could not be planted with anything." Her debts were a constant source of worry, and she feared that her youngest son would have to drop out of school to find work.

Had the saline intrusion not come, her family would have harvested winter–spring rice and prepared for the summer–autumn crop. But the family's entire area of rice was damaged. They did not even have straw for their cows.

The impacts were felt across the whole community. With water sources dried up or saline-contaminated, many of the poorest families were forced to buy fresh water for their daily needs, at a price they could not afford. "Many also took out loans for rice seedlings and fertiliser, which they are now struggling to repay," she revealed. "The saltwater intrusion left the river water too salty for either human or animal consumption, or to irrigate crops.

"I do not know what can help alleviate the situation. I simply store fresh water into the water tanks provided [by the government with the support of UNDP] to prepare for the next disaster," she added. She expressed her wish to have a better and resilient future for her children.

A 2016 UNDP report, *Viet Nam Drought and Saltwater Intrusion*, showed that following the 2015/16 El Niño phenomenon, saltwater intrusion extended up to 20 to 30 km further inland than average – up to 90 km in some areas. While this is an annual occurrence, the level of intrusion – caused by poor rainfall, reduced flow in the Mekong River and groundwater depletion – was the most extensive ever recorded. In 2016 alone, 659,245 hectares of cropland were damaged to varying degrees – including more than 273,000 hectares of rice, the staple crop. Of the total damaged rice crops in the 18 most affected provinces, 161,030 hectares or 53.2 per cent suffered losses of 70 per cent of production or more, classified by the government as 'extreme loss'.

UNDP's recommendations

Sustainable and climate-resilient development of the Mekong Delta is essential for achieving the Sustainable Development Goals across Viet Nam as a whole.

The Mekong Delta and its inhabitants are increasingly impacted by sea-level rise, flooding, typhoons and storm surge, as well as by drought and decreased river discharge. These trends are exacerbated by climate change and drive knock-on impacts including land subsidence, saline water intrusion and coastal erosion. The government is committed to supporting transformative sustainable development for the Delta, and swift action is required.

Sustainable and climate-resilient development in the Delta requires learning to make nature and natural resources work for, not against, us. This can only be achieved through joined-up and integrated planning, where at least some resources are jointly

▲ Ms Nguyen Thi Nuong, a widow living in the Mekong Delta of Viet Nam. Her home was destroyed by a hurricane in 2006 and she had to sell half her land after the drought of 2016. Now saline intrusion is making her crops unfit for human or animal consumption

managed. It also requires a consultative and participatory process, harnessing the knowledge of the diverse cultures and experience of the people in the region, and focusing on building their resilience. And it requires provinces to work together as a united area, not as single entities confined by administrative boundaries.

Making better use of the services provided by nature requires building on traditional approaches, such as 'living with the floods'. Instead of fighting the climate and building higher dykes to block water, we should aim to understand natural dynamics and harness them to improve the quality of the landscape. We need to apply approaches such as ecosystem-based adaptation that can foster water retention for the dry season and groundwater replenishment during natural flooding.

As the climate changes, we will need innovative approaches that build sustainable resilience during droughts and periods of increased salinity. More research is needed to identify options that capitalise on natural assets, and recognise the trade-offs in land and water management – for example, between rice cultivation and water retention, or between rice production and aquaculture.

Planning and working together beyond administrative boundaries requires a real shift in thinking and integrated planning, with financial incentives. We believe that the 'Mekong Delta Development Master Plan on sustainable development and climate change adaptation', currently being put together, is essential. This should serve as the basic foundation for planning, budgeting and investment in the Delta. It will support the optimisation of short-term investment decisions, and consider the long-term and sometimes uncertain impacts on the ecosystem and the need to increase resilience to cope with future pressures.

It is time to rethink development and renew actions to support people's resilience. The process of identifying challenges and local solutions, planning, budgeting and investing should start with consultation. Dialogue must include stakeholders at all levels, in particular farmers and vulnerable groups. This can help to raise public awareness and mobilise viewpoints to inform decision-making, while ensuring that new transformative models are accepted in society.

Fostering consensus among government agencies, provinces, businesses and citizens is essential for securing the sustainable and climate-resilient development of the Mekong Delta. ●

From disaster to opportunity

With the right support, vulnerable communities can adapt to the escalating effects of climate change. We must do more – now – to help them

Much of the talk around climate change focuses on the future. Creating a clean, green and sustainable planet should be everyone's priority. But we must not forget that climate change is already impacting the lives of millions of people around the world.

Many of the biggest humanitarian crises we face today can – at least in part – be traced back to climate change. Even the smallest changes in rain patterns or water levels can have massive impacts. Stronger and more frequent storms destroy livelihoods and livestock, drought and soil salination cause crops to wither and die, and rising water levels force people to flee their homes and land. Evidence shows it's the world's poorest people – women, in particular – that are hit hardest.

Urgent action is needed to not only reduce emissions, but also to make communities more resilient to the impacts of climate change. Whether it's coffee producers in the mountains of Honduras, rice farmers in Nepal or dairy farmers in Kenya, they are all increasingly vulnerable to the changing climate. But there is a lot that we can do to support them – and if we get it right, these communities can thrive and grow.

Two years ago, Haiti was hit hard by Hurricane Matthew – one of the worst storms the world has ever seen. While many people moved to shelters and prepared to ride out the storm, some of Haiti's poorest communities were unaware of what was about to happen.

More than 6,500 families that Heifer International works with found themselves in the path of the storm. They spent a number of long, dangerous days and nights taking shelter, trying to keep their families and livestock safe.

Although many lives and livelihoods were lost as the deadly storm made its way north, it also brought new life to the drought-hit community of Cabaret in the north-west of the country.

Years ago, Cabaret was home to a 25-acre swamp called Mare Verger. The soil around the swamp was good for farming and the fields were packed with squash, pumpkins and enough healthy food to feed local families. But by 2000, water levels in the swamp had already fallen dramatically. Two years of severe drought from 2013 to 2015 made the situation even worse, and it dried out completely. Crops withered and died, and farmers in the community increasingly chopped down the remaining trees to produce charcoal – one of their few sources of income.

Dugat Esaie, a local farmer from Cabaret, describes how the drought made it very difficult to get water for animals and even harder to grow crops: "I used to have to walk miles every day to get fodder and water for my livestock. I tried growing sorghum for part of the year

because it needs less water, but I would often lose the harvest because it didn't rain at all."

With the trees gone and the topsoil washed away, the swamp became caked in mud that set hard like cement. After the 2010 earthquake, Heifer International had started working with the community on a range of income-generation activities. But plans to produce fodder and food crops failed, as the soil was completely leeched of nutrients. It was clear that the key to tackling hunger and improving food security in Cabaret lay in supplying water to the farming families, who were spending hours every day walking long distances just to get enough to drink.

A plan was put together to turn the old swamp into a lake which, when full, would have the capacity to irrigate 250 areas of farmland. Heifer provided the funding to re-dig the lake, and rainwater harvesting would keep it topped up. But a large supply of fresh water was needed to get it up and running. That's when Hurricane Matthew hit.

Despite leaving a trail of death and destruction across the country, when the storm clouds from Hurricane Matthew lifted, people from the community of Cabaret saw that the lake was almost completely full of water. The surrounding land has once again become valuable for growing food, and farmers have boosted their income by selling surpluses in the local markets.

Now that they have water for irrigating their crops, farmers like François Wilman are able to grow sorghum, corn and beans, and can harvest their crops three times a year.

Urgent action is needed to make communities more resilient to the impacts of climate change

"With the construction of the lake this area has changed completely, because many farmers like me are now able to grow corn, sorghum, beans and fresh vegetables easily with the water from the lake. With increased production, my family has been able to eat more and better food, and my income has increased considerably. Our community as a whole is now much more food secure."

Much of the farmland is now back in production and the food security of local families has improved, but the lake is also providing much more than water for farming. Hundreds of livestock use it every day, and the community has introduced 5,000 fish, which serve as an important source of protein.

In total, more than 17,000 people are benefiting from the increase in food production linked to the lake. The lake remains at about 70 per cent capacity and the community has dug a network of channels to funnel storm water from the hills into the lake so that it continues to be replenished.

"The last two years have been a blessing for my community," says Dugat Esaie. "First, more production, income and quality of life of the farmers and their families. Second, no more losing our animals because of lack of water and food. The irony is that the lake was filled completely by Hurricane Matthew and subsequent storms that brought misery and destruction to many other people."

With the right support, farming communities like the one in Cabaret, Haiti, can adapt to the changing climate, increase their incomes and become more food secure. Farmers raising cows and goats can shift to zero-grazing practices, coffee farmers can diversify their crops to become less vulnerable to pests and disease, and millions of farmers can benefit from adopting climate-smart agriculture practices such as soil and water conservation, and watershed management. These are just a few examples.

Of course, this does not replace the need for strong international processes that reduce emissions, but by working with local farmers to adapt to climate change, they can get the support they need today and be part of the solution to the climate crisis. ■

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UNA-UK thanks Heifer International for its generous support for this publication

Lake Verger in the community of Cabaret, Haiti. With storm water captured in the lake, poor families can irrigate crops and breed fish. Supported by Heifer International's Haiti team, the community released 5,000 fish into Lake Verger, giving them an important source of nutrition (Images © Lacey West/Heifer)

Halting the desert

China's efforts in curbing the march of the Gobi could show how the rest of the world might tackle desertification

By **Jenny Choo**, Coordinator, Land for Life Programme, United Nations Convention to Combat Desertification (UNCCD)

For decades, scientists and residents have been trying to tame the advancing sands of the Gobi Desert. Desertification – a major ecological problem that adversely affects 400 million people in China – is claiming thousands of hectares of land each year. To date, more than a quarter of the land area in China (about 2.61 million square km) has been degraded due to desertification. This poses an economic challenge to people in the affected areas and is forcing many to leave their homes.

As well as impacting agricultural production, desertification also affects transportation and communication systems. The economic costs of desertification between 2002 and 2006 have been estimated at RMB 64.2 billion – or about $8 billion – per year.

Of course, China is not the only country that suffers from desertification, land degradation and drought. These hazards, though climate-related, are largely caused by human activities such as overgrazing, inappropriate land use, over-cultivation of vulnerable areas, deforestation, wasteful use of water and population growth. Around the world, approximately 12 million hectares of productive land are lost each year. According to the UNCCD, 169 countries declare themselves affected. The most vulnerable regions are the drylands – semi-arid and dry sub-humid areas that cover about 41 per cent of the global land surface and host one third of the world's population.

China has emerged as a champion in the fight against desertification. It has invested heavily in land restoration efforts since the 1960s through several major initiatives.

The Three-North Shelterbelt programme is a national tree-planting project designed to halt the spread of the desert and to rehabilitate the degraded ecological system. Also known as the 'Green Great Wall of China', so far more than 66 billion trees have been planted. The programme aims to rehabilitate degraded land and stop the desert encroaching into the fertile grasslands and farmlands of northern China.

The project has already successfully restored 45 million hectares of land affected by soil erosion and afforested another 29.2 million hectares of degraded land, according to the National Forestry and Grassland Administration. The programme will continue until 2050, by which point the belt of trees will be 4,500 km long.

To scale up measures against desertification, the Chinese government has also developed a National Action Programme to Combat Desertification by expanding protected areas and restoring overgrazed and marginal farmlands to their natural state. It has created strong incentives to encourage private-sector organisations to invest in restoring degraded areas through public–private partnerships. Farmers and herders can get subsidies if they carry out land restoration work.

In 2016, China launched the Belt and Road Joint Action Initiative to combat desertification across the Silk Road region. Cooperation with partner countries and communities will accelerate in the future.

The Minqin Initiative is one of many success stories that illustrate how China has managed to significantly lower the threat of desertification after decades of restoration efforts. Surrounded by two large deserts – the Tengger and Badain Jaran, both part of the larger Gobi – Minqin County in Gansu province is a major source of dust storms that put millions of people in China and neighbouring countries at risk.

After overcoming some initial challenges, Minqin communities have successfully restored 153,240 hectares of forest. More than 300 km of the 408-km desert boundary are now fortified with trees. Forest coverage of Minqin reached 17.91 per cent in 2016, compared to 11.52 per cent in 2010, according to the state's desertification control assessment.

China has emerged as a champion in the fight against desertification. It has invested heavily in land restoration efforts since the 1960s through several major initiatives

Minqin's battle against the spread of the Gobi Desert can be dated back to the 1950s. A Minqin resident, Mr Guirong He, has described the devastation caused by desertification and dust storms in the past. "We lost 38,000 hectares of land that was used to cultivate millet, maize and other vegetables," he recalls. "Ninety per cent of young seedlings that we planted were swept away by sands and died. Fifteen thousand trees were uprooted, destroying about 1,000 hectares of reforested area."

After such devastation, the success of the Minqin Initiative is bringing new hope. During the recent Belt and Road International Forum on Public Cooperation

▲ Planting sacsaoul in Minqin County, in northwest China's Gansu Province. Minqin County, bounded on three sides by deserts, is a conspicuous success story in the fight against desertification

for Ecological Remediation, Haixuan Tao, the Head of Administration of Liangucheng Nature Reserve of Minqin County, said: "Life back then was like living at the edge of danger, and that is why the locals called this place 'Hu Kou' – literally translated as 'Mouth of Tiger'. At one time, it was threatened by the biggest dust storm, which almost buried the village, and many families were forced to leave their homes.

"This year, on 21 May, we had another strong wind in Minqin. The wind speed was recorded as grade 8. But there was little sandstorm to be seen in Minqin compared to earlier years."

The success of Minqin is not limited to afforestation activities. What amazed experts is the revival of Qingtu Lake, along with neighbouring wetlands and small streams. The lake, which was previously drying out at an alarming speed, has now stabilised. Water levels are increasing. This has prevented the Tengger and Badain Jaran deserts from merging. In addition, the planting of local herbal shrubs Haloxylon and Cistanche as part of the restoration project has created direct and indirect job opportunities for 114,000 people.

Other initiatives

Other success stories include innovative public–private models of cooperation. These include the restoration of nearly 40,000 hectares of degraded grassland in the Alashan Plateau led by the China Green Foundation, local communities and government. The Inner Mongolian local governments have partnered with Elion Resources Group to restore 600,000 hectares of degraded land in the Kubuqi Desert. And the Ant Forest app, introduced by Ant Financial Services (a subsidiary of the Alibaba Group), has encouraged urban residents to reduce their carbon footprint and help restore land that is degrading. Low-carbon activities by the app's users, such as walking or taking public transport, are measured and converted into virtual 'green energy'. This grows virtual trees in the user's account, which are then converted into real trees that are planted in the desert.

These are clearly big successes, but the fight against desertification must continue – in China and beyond. With a growing population and a warmer and drier climate, the challenges will increase. We must ask what we can learn from China's experience, and seek to balance the needs of socio-economic development with the protection of vital and limited natural resources. ●

With thanks to Xiaoxia Jia (UNCCD) and Jiajia Luo (China Green Foundation) for providing information on the Minqin Initiative and the Alashan Plateau restoration.

Storm protection

Hurricanes have taught Americans hard lessons about safeguarding communities before, during and after an extreme weather event. What can the rest of the world learn from the US experience?

◀ A resident of Panama City, Florida, surveys the remains of her home after it was destroyed by Hurricane Michael

By **Carol Werner**, Executive Director, and **Amaury Laporte**, Communications Director, Environmental and Energy Study Institute (EESI)

Michael, Florence, Harvey, Irma, Maria, Sandy, Katrina… these friendly names have acquired a hard edge. Together, these hurricanes have created more than half a trillion dollars in damage and caused the deaths of at least 5,210 people. Climate change is making such devastating storms more likely and more destructive, by adding heat to the atmosphere and seas. Storms are powered by heat: the more heat there is, the more powerful storms can become (and the more likely they are to develop).

According to the 2017 National Climate Assessment, the United States is already experiencing more hurricanes due to global warming, as well as more heatwaves, heavy downpours, floods and droughts. Indeed, 2017 marked a sobering record for the nation: 16 disasters cost more than a billion dollars each, resulting in more than $300 billion in damage in all – more than in any other previous year. The number of 'billion-dollar' disasters (after adjusting for inflation) is rising. Between 1980 and 2012, the US experienced an average of 5.3 such disasters per year. In the last five years (2013 to 2017), the average jumped to 11.6 per year. The current year is, sadly, shaping up to be just as devastating, with 11 billion-dollar weather disasters as of mid-October.

The facts are clear: the United States is experiencing more climate disasters and the country needs to do more to protect its citizens. With four out of ten Americans living on the coasts, the country is particularly vulnerable to ocean storms. Making coastal communities more resilient is critical. It's also financially astute: it's much cheaper to invest in resilience than to rebuild. Government-commissioned studies by the National Institute of Building Sciences found that every dollar invested by the federal government in adaptation measures provides $4 to $6 in future benefits. Some experts even estimate that the benefits are closer to $10 for every $1 invested, when you take into account insurance costs, property loss and other factors.

Investing in resilience aligns with sustainability goals, such as the 17 Sustainable Development Goals (SDGs), adopted by world leaders in 2015 and meant to be achieved by 2030. Two examples are SDG 9 (industry, innovation and infrastructure) and SDG 11 (sustainable cities and communities). Both prioritise making cities and their infrastructure more resilient and sustainable.

Resilience is a core element of our work at the Environmental and Energy Study Institute (EESI). Through a multi-year Congressional briefing series, *Building Resilient and Secure Infrastructure*, we are focusing attention on federal investment in adaptation and resilience measures to make extreme weather events less devastating. We're also pushing for smarter and stronger rebuilding, so that communities are better prepared for the next disaster. US coastal communities have learned several lessons and best practices from past hurricanes, and we are sharing those lessons far and wide. Indeed, planning and coordination among local, state and federal agencies has been shown to be an absolute 'must'.

Making coastal communities more resilient is critical. It's also financially astute

The need for better land use and green infrastructure

The best way to protect buildings in vulnerable locations is not to build them there in the first place. Naturally, the wholesale move of communities is usually not practical. But when communities have been devastated by a disaster, it is worth considering whether it makes sense to rebuild them in the same place. Governments can help ensure proper land use by developing better risk mapping and analysis tools. Local communities need detailed, up-to-date maps that properly reflect the risks of flooding, preferably at the level of individual properties.

Some US communities, particularly in the north-east, have reconverted ravaged coastal lands into natural buffers against the sea. Green infrastructure such as wetland restoration, rain gardens, green roofs and

permeable pavement help absorb storm surges and rainwater, thereby reducing flood risks. And many of these projects also help sequester carbon (as plant matter), keeping it out of the atmosphere where it would contribute to climate change.

The need for strong building standards

Hurricane Andrew was an eye-opener in the United States. In 1992, it destroyed 28,000 homes and caused $26.5 billion in damage in south-east Florida. Local authorities have since made their building codes much tougher.

run. For homeowners, even inexpensive reinforcements (such as extra nails or special metal connectors) can make a big difference. In many cases, fortified homes will pay for themselves through lower insurance premiums and utility bills.

The need for robust public shelters

Making all existing buildings in a community more resistant to extreme weather can be cost-prohibitive. In many cases (especially in poorer communities), the best solution is for residents to seek refuge in fortified public buildings, such as community centres, medical centres, schools or universities. Public officials should ensure that such buildings are indeed capable of resisting extreme weather and can accommodate large numbers of people during emergencies. Moreover, governments should lead by example, and follow best practices to make their buildings and infrastructure as resilient as possible.

Resilience isn't only about surviving a disaster. It's also about getting back to a normal life as soon as possible. By hardening critical infrastructure, communities can prevent population displacements and devastating financial losses

The Federal Emergency Management Agency (FEMA) has said that "disaster resilience starts with building codes" and is now encouraging local communities throughout the US to adopt up-to-date codes and enforce their application. The Insurance Institute for Business & Home Safety (IBHS), a non-profit research organisation, has developed the FORTIFIED home standard, which puts a particular emphasis on roofs. Indeed, one of its executives notes that, "without a roof, a house is a bucket waiting to be filled with water".

As an added bonus, resilience often goes hand in hand with efficiency. Analysts have found that homes built to be more energy efficient (with strong, leak-resistant windows) are more resistant to high winds, requiring fewer repairs after storms.

We know how to make strong buildings that can endure disasters, but we aren't always prepared to pay the price for them – even though it's more cost-effective in the long term. The Obama Administration estimated that more stringent standards for federal buildings would increase construction costs by 0.25 to 1.25 per cent, but the more durable buildings would save taxpayers money in the long

Hurricane Katrina, which struck New Orleans in 2005, demonstrated that buildings being used as refuges must not only be protected from storms, but also from the weaker buildings around them. During the hurricane, many sought shelter in the Superdome, a sports stadium. It was resisting well, until the windows in a nearby high-rise hotel all shattered. The shards penetrated the Superdome's roof, making it possible for the storm's winds to rip it off, leaving those inside exposed to the weather.

The need for a resilient, decentralised grid and other critical infrastructure

Most Americans take electricity for granted. We flip a switch and voilà: instant refrigeration, heating, cooling, communications and so on. But Hurricane Maria showed us that taking electricity for granted can be deadly. The long-lasting blackout it caused may have led to more than 1,500 deaths in Puerto Rico – a US territory, according to Harvard researchers. With life-saving equipment and air conditioning units inoperative, the sick and elderly became even more vulnerable. Thousands more lives were lost in the months following the hurricane than during the actual storm.

The solution is clear: microgrids, smart grids, renewable energy and storage systems. These can provide resilient power to communities, making them less dependent on vulnerable central power stations and transmission lines. When midtown Manhattan was shrouded in darkness during superstorm Sandy, New York University was able to keep most of its lights on thanks to an independently powered microgrid. Once again, there is an extra benefit to investing in resilience: making electricity supply and distribution more resilient often is less carbon intensive and more efficient.

The need for resilience extends to other critical infrastructure as well, such as roads, bridges, airports and sewer and water systems. Resilience isn't only about surviving a disaster. It's also about getting back to a normal life as soon as possible following a disaster. By hardening critical infrastructure, communities can prevent population displacements and devastating financial losses that make it harder for a community to return to normal.

Some argue that talk of adaptation and resilience will detract from the underlying need to stop releasing greenhouse gases. While reducing our emissions is critical, sadly, we are already experiencing significant impacts of climate change. We must act to protect ourselves now, which means tackling mitigation and adaptation simultaneously.

As we have seen, actions taken to make communities more resilient often make them less polluting. For example, installing decentralised renewable-energy systems makes communities more self-sufficient and reduces fossil-fuel emissions. Resilience and sustainability are two sides of the same coin: protecting our communities while protecting our environment. ●

Climate and migration

There are many reasons why people continue to risk their lives in perilous journeys across the Mediterranean, despite the rising death toll. Environmental factors are significantly contributing to the crisis

By **Laurel Hart**,
United Nations Association-UK

Migration in the Mediterranean hit the headlines in 2015 as Europe faced a sudden influx of migrants fleeing predominantly from the Middle East, sub-Saharan Africa and North West Africa.

In 2015 alone, over one million refugees entered Europe. It's estimated that half of these came from Syria, a fifth from Afghanistan and seven per cent from Iraq, with most of the remaining third heading from sub-Saharan Africa. Since 2015, arrival numbers have dropped significantly but the proportion of those losing their lives while trying to make the crossing has risen dramatically. The Mediterranean remains a major transit point.

Many of those arriving on the shores of Europe are refugees who have fled their homes to escape protracted conflicts in Africa and the Middle East. Others are migrants, who have embarked on this perilous journey for a number of factors, including extreme poverty.

Most cross the Mediterranean by sea via one of its main migratory pathways. The

▲ **A feeding centre in Mogadishu, Somalia, during the severe drought in 2017**

Central Mediterranean Route – one of the most consistently busy and deadly – goes from North Africa (mainly Libya) to Italy. The Western route involves journeys from Morocco to mainland Spain by sea, including land crossings into Spanish enclaves. The Eastern route sees crossings from Turkey to Greece.

Since 2015, individual governments and the EU have spent much time and money on efforts to reduce irregular migration. Some governments have tightened their borders, even closing them temporarily and calling for the EU to do the same.

The EU has spent millions trying to dissuade those making the journeys by funding and supporting countries that act as main points of entry: for example, giving over $200 million to help Sudan stem migration to Europe. It also struck a controversial deal with Turkey in 2016, which led to an immediate, notable drop in migration to Greece.

However, criticism is mounting that these approaches are not only ineffective but are also putting migrants in direct harm. Research suggests that security-based interventions designed to tackle the flow of migrants, refugees and asylum seekers have played a key role in increasing the vulnerability of people on the move. For instance, smuggling and trafficking networks have mushroomed in Libya, as migrants from sub-Saharan and North Africa pass through. Last year, shocking footage emerged of 'slave' auctions in the country.

A containment approach to migration disregards the root causes that force people to take such life-threatening journeys. It also ignores the fact that some migrants, notably refugees, have legal pathways open to them under longstanding international agreements, such as the 1951 Refugee Convention.

Without efforts to address root causes, and without an adequate humanitarian response, security-based measures will only lead to more deaths, while smuggling networks will continue to profit from those tragedies at sea. States, European and African, must put the safety of those on the move at the heart of their responses.

The role of climate change

Climate change is making this challenge even more urgent. Despite contributing the least to global greenhouse gas emissions, Africans will be among those who suffer the most. North Africa is one of the hot spots for extreme heat, drought and aridity arising from climate change, with rising temperatures predicted to reduce significantly the amount of arable land, shorten the length of growing seasons and reduce crop yields.

Climate change will drive a huge increase in the number of migrants seeking refuge in Europe.... Forcing people to remain in their country of origin is simply not going to work

As a region highly dependent on climate-sensitive agriculture, the economic and social conditions in North Africa are likely to deteriorate in the future. Climate change is already placing an extra burden on the abundance of resources, aggravating existing conflicts and reducing the options of people to successfully address these challenges to their livelihoods. The expected decrease in annual precipitation, for example, is likely to hit food supply in areas that rely on irrigation for crop growth, and drive conflict over dwindling water sources.

Even if the world meets the 2ºC target set out in the Paris Agreement, it would do little to stop the region from overheating. A temperature rise of 2°C over the next 80 years could increase desertification, with both the Sahara and Sahel moving south – and people more likely to move out.

The latest Intergovernmental Panel on Climate Change (IPCC) report concludes that a world with 2°C of global warming will lead to more heat-related deaths, reduced crop yields, more extreme weather events, slower economic growth, increased poverty, and more people facing water stress (by up to 50 per cent) than a 1.5°C world – the 'stretch' target agreed at Paris. And, predictably, the impacts will get progressively worse if temperatures warm beyond the 2°C limit.

To address this, all states need to rapidly increase the scale and ambition of their nationally determined contributions. Currently, we are on course for a temperature rise of 3.1-3.7°C, with plans in place that would reduce this by about half a degree. We also need to see more support for improving adaptation strategies, including for migration.

Improving responses?

Studies suggest that climate change will drive a huge increase in the number of migrants seeking refuge in Europe if current trends continue. Forcing people to remain in their country of origin is simply not going to work.

Moving forward, climate policy needs to integrate migration concerns and take a comprehensive rights-based approach. For instance, we need to look closely at what resources are needed to support least developed countries, which have fewer resources to put towards adaptation, so that migration is not the only viable option open to people – most of whom will not want to leave their homes. This means ensuring that local voices are heard, so that local needs can be met.

We also need to review existing legal frameworks which are ill-geared to deal with those displaced for environmental reasons. The Global Compact for Safe, Orderly and Regular Migration is a positive step – but it is only the first that we will need to take to tackle the complex root causes of migration, and the responses they require.

Climate change and its effects will remap our world, altering not just how we live but where we live. If we want to help people avert the need to migrate from their homes, then getting ahead of global climate change trends is critical. ●

On migration: Palermo's perspective

According to the World Bank, climate change could displace some 150 million people by 2050. While many governments have sought to close their borders, the Sicilian capital has welcomed migrants, with inspiring results

By **Leoluca Orlando**, Mayor of Palermo

"How many migrants do you have in Palermo?" This is one of the most common questions I get asked when talking with foreigners or journalists about the migration policy of our administration.

The answer is simple and yet complex at the same time: no one single migrant lives in Palermo, because all people living or arriving in Palermo are considered to be Palermo's citizens – or Palermitani. Of course, this answer does not consider the legal aspect of citizenship. The mayor or

▲ 358 migrants, rescued between Sicily and north of Africa, disembark from Italian Navy ship *Libra* in Palermo

municipality do not, according to Italian legislation, have the power to award Italian citizenship by themselves. What we do have, however, is the possibility to promote and build a welcoming environment, reflected and supported by a welcoming policy and a welcoming set of services. This is Palermo today. Migration flows, meanwhile, have fallen drastically since 2014–16, when more than 35,000 migrants arrived, escaping from violence, poverty, disasters and war.

Five years ago, the Mayor proposed, and the City Council created, a so-called 'council of cultures'. This is an official body comprising 21 citizens elected by and representing all those living in Palermo that hold a passport other than an Italian one. Each geographical area of the world is represented, in proportion to the presence of those communities now in Palermo. The current president is from Côte d'Ivoire, supported by a vice-president from Sri Lanka. Past presidents have been from Palestine and Cape Verde. More than half of the members are women, many of whom are active in local civil-society organisations. The council is not only a place where the interests of different communities are represented, but is also where many intercultural initiatives are organised and proposed to the city. It's the place where the slogan 'all different, all equal' becomes a daily truth.

The council of cultures represents the tip of a vibrant and diverse iceberg. In Palermo every culture and religion is considered as part of what I call 'Palermo's mosaic'. Each small piece of the mosaic has its own role. Everyone's role is relevant, but only by looking at the full picture can you understand the beauty and balance of the image.

A different approach

Is this just a 'humanitarian' approach to migration? No, it is not. We choose to refuse both humanitarian and security approaches to the migration issue.

If you use a security approach, there will always be someone who has a more secure answer to the problem. If you say: "We should not give freedom of movement in Europe to migrants", there will be someone who will say, "We should not allow them to enter Europe at all". And if you say: "We should not allow them in Europe", there will be someone else who will say, "We should shoot their boats in the Mediterranean".

If you choose a purely humanitarian approach, there will always be someone or some state that is poorer or more fragile than another, and which you feel you must prioritise, that in the end you will not recognise migrants' rights.

We have chosen a different approach. This is summarised in the Charter of Palermo, a document approved in March 2015 by lawyers, representatives from NGOs and public officers. The simple idea behind the charter is that every single migrant is a person and, as such, owner of all human rights. This may sound obvious. But in today's political scenario it is frankly revolutionary to say that mobility is a human right – in other words, a fundamental and basic human right for all.

In the hyper-connected world in which we live, almost everything has freedom of movement but people. You can move goods, money or data fairly easily. But you cannot freely move if you are a person from the 'wrong' country.

If, however, you look at migration as a natural human phenomenon, as the consequence of a desire for a better life, of a yearning to escape poverty, disasters, wars and violence of different kinds, then you can only assume that any limitations to movement are a new form of slavery. In many cases – the Mediterranean, the Balkans, the Mexican–US border, as well as others – limitations to movement can be viewed as a new form of mass death penalty.

But back to Palermo. Even if we promoted the abolition of the so-called 'permit to stay', we (as a municipality) have no power to change our national laws on migration or citizenship. So what practically can we do? The answer is that we can – and do – take concrete and symbolic actions every day.

The Mayor of Palermo – a Catholic – officially participates in all religious celebrations of the city's communities: Muslim, Jewish, Hindu, Buddhist and Christian Orthodox. He participates not in a private capacity, but instead wears the tricolour band that is the official symbol of his public authority and representation of the state. This makes it possible for each Muslim, Jewish, Hindu or Buddhist believer to feel and be perceived as a citizen of Palermo.

Unlike in other Italian or European cities, if a Muslim who is perceived as dangerous arrives in Palermo, the first one to alert authorities is the Imam. Why? Because the Imam feels he is part of the community and because he cares for the community.

If a Muslim who is perceived as dangerous arrives in Palermo, the first one to alert authorities is the Imam. Why? Because the Imam feels he is part of the community and because he cares for the community

Only in Palermo can Catholic authorities donate to the Jewish community to transform a former church building into a synagogue. Only in Palermo do Hindu and Muslim believers volunteer to be part of the team that moves the heavy chariot for the 'Festino', the most important Catholic festival in honour of the patron saint of the city. This same open and inclusive approach is applied in every aspect of our municipal life.

In the rest of Italy, many municipalities run by Lega (a national far-right political party) or other right-wing mayors look for ways to exclude children from migrant families from public services such as kindergartens or school canteens. In Palermo, we try to make these services as cheap as possible and free for families in

▲ A 'No Borders' street party, organised to promote racial unity, in the Ballaro market area of Palermo, Sicily

financial hardship, whether from a migrant background or not.

In Italy and Europe, people willing to welcome refugees and migrants into their home do so without a legal framework to refer to. In Palermo, we established and promote an official list of voluntary tutors for young unaccompanied migrants. We give those tutors training, legal counselling and official status when dealing with the authorities. I could go on, but hopefully it is clear why we talk of Palermo as a model, particularly when compared with the realities migrants face elsewhere in Europe and beyond.

One of the obvious criticisms of our approach is that Palermo is too small to welcome all migrants. This is true, and it is true to say that Italy, too, is too small. But what if we talk of 27 or 28 European countries? What if we talk of more than 500 million European citizens compared to the small number of migrants arriving in Europe? Is Europe really too small?

Added benefits

Let me also say that welcoming migrants benefits our city as a whole. Just as some years ago when convincing people to fight against the Mafia I had to explain why legality is economically beneficial, now I assure people that opening our city is beneficial too. Thanks to our recognised policy of welcoming migrants, Palermo has become one of the most important tourist destinations in Italy over the last few years. While the entire tourist market in Italy grows between three and four per cent per year, every year Palermo welcomes some 15 to 18 per cent more tourists than the previous year. While the economic crisis continues to strangle small and medium-sized businesses throughout Italy, in Palermo our economy is showing signs of recovery, driven by the tourist boom and the city's new cultural vitality.

Once known as the Mafia's capital, in 2018 Palermo was awarded the Italian Capital of Culture. The reward reflects not just the city's arts nor how its architecture still illustrates the many people that have lived here over centuries. It is our culture of welcoming, of multiculturalism and our approach to migration that has turned Palermo into a place opportunity – for all communities. ●

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Published by
Witan Media Ltd
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Painswick, GL6 6XH, UK
Tel: +44 (0)20 3327 3730
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Front cover: Firefighters douse the Casa Loma fire station as flames approach in the Santa Cruz Mountains, California. The amount of land ravaged by wildfires in the USA has increased as temperatures have risen. The area burnt annually is now double that in the 1980s and 1990s.
(© Josh Edelson/AFP/Getty Images)

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Printed by: Buxton Press
ISBN: 978-1-9998451-2-4

Climate 2020: sustainability

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About us

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The United Nations Association – UK (UNA-UK) is the only UK charity devoted to building support for an effective UN, and a vibrant grassroots movement campaigning for a safer, fairer and more sustainable world

In 1945, the creation of the UN reflected the hope for a better future. Since then, UNA-UK has enabled ordinary people to engage with that promise, by connecting people from all walks of life to the UN and influencing decision-makers to support its goals.

Today, the need for the UN has never been greater. Thanks to the organisation, millions of people now live longer, safer and healthier lives. But far too many people still die each year from violence, disasters and deprivation. The death toll from conflicts and emergencies is rising. More people have been forced to flee their homes than at any other time since records began. And across the world, our fundamental values are increasingly under attack.

Climate change is the defining issue of our time and the most obvious case for more and better global cooperation: it cannot be solved by one government – or indeed by governments – acting alone. The UN is the only organisation with the reach, remit and legitimacy to mount the urgent, coordinated response we need.

The 2030 Agenda and Paris Agreement demonstrated the UN's ability to forge solutions, even in uncertain times. But making these commitments a reality for all the world's people will require political will and public buy-in on a scale never seen before.

Please support us

UNA-UK is ready to play its part. We serve as a bridge between governments, the UN and the public. We lobby for joined-up thinking on peace, sustainable development and human rights. We work with experts and practitioners to find new ways to tackle the challenges we face. Through education and training, we equip young people to play a role in international affairs. And by demonstrating why the UN matters, we encourage people to act on their responsibilities as global citizens.

But we have a tiny budget and just six members of staff. With donors focusing on immediate demands, grants for vital long-term work are dwindling. We are now facing a serious funding shortfall and need to raise £600,000 by 2020 – the UN's 75th anniversary – if we are to secure our future. ●

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