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ENGINEERING
A BETTER
WORLD

Achieving the United Nations
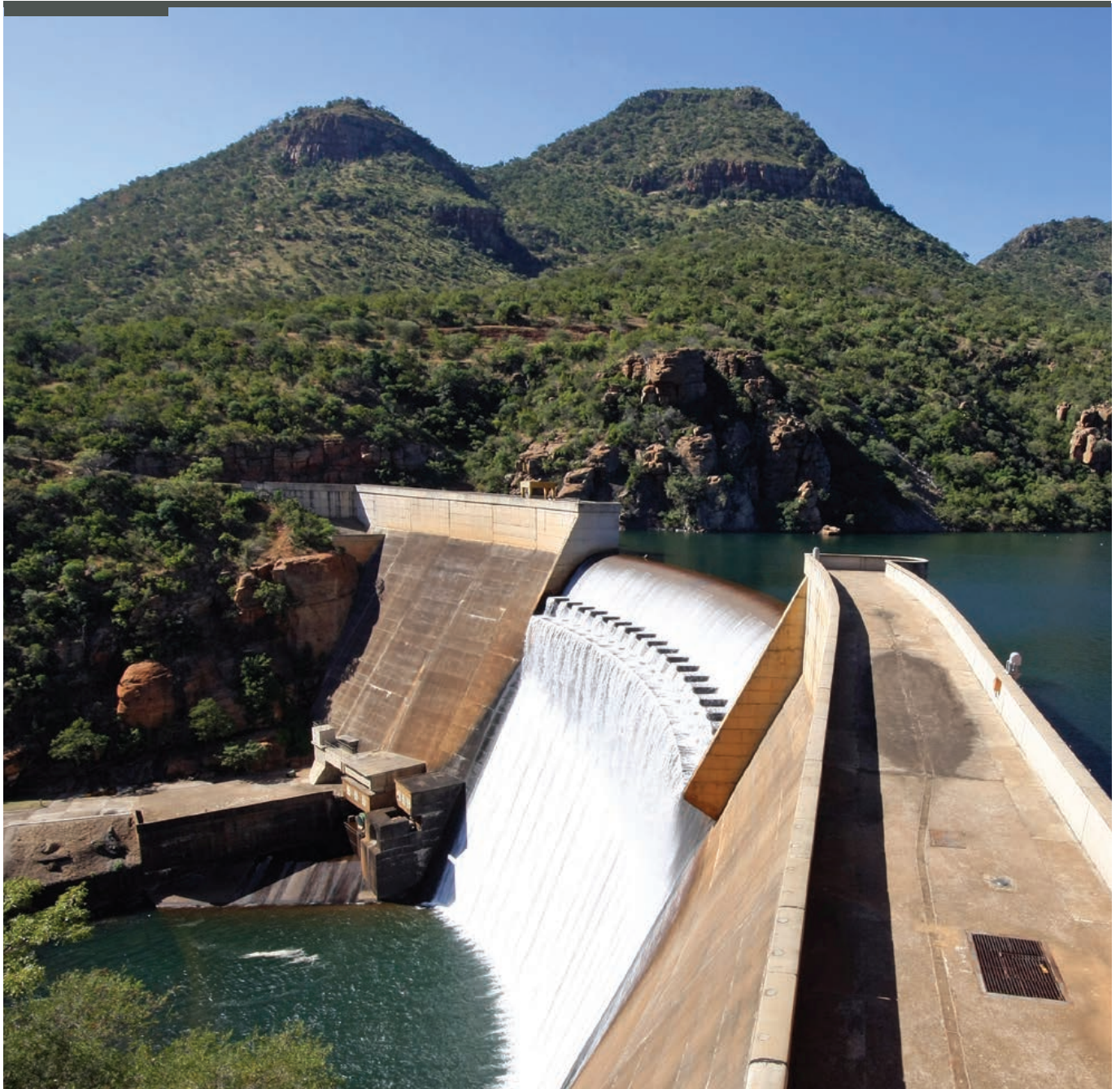Sustainable Development Goals

Chileshe Chanda borehole rehabilitation, Hamakumo Village © WaterAid

ENGINEERING A BETTER WORLD

Achieving the United Nations Sustainable Development Goals

CONTENTS

Dame Ann Dowling OM DBE FREng FRS, President, Royal Academy of Engineering

ENGINEERING OUR WAY TO A SUSTAINABLE FUTURE FOR ALL

The 20th century saw unprecedented progress in improving standards of living. Electricity gave billions lights after dark, the internet connected continents at lightning speed, transport evolved from horse and cart to space travel and vaccines were developed for some of the world's biggest killers, with diseases like smallpox completely eradicated.

These developments and thousands of others like them have transformed lives. Together, they have immeasurably changed the social and economic progress of humanity. We have engineers to thank for driving this progress.

But we are far from finished, and many more global challenges remain, as highlighted by the UN Sustainable Development Goals (SDGs). Over 1.1 billion people still don't have access to electricity[1], 2.4 billion do not have adequate sanitation and 663 million people lack access to clean water[2]. Furthermore, about one third of the world's population is not served by all-weather roads.[3]

Technology and infrastructure – both improved access to existing solutions and new innovations – will be key to addressing these problems, and enabling growth in trade, access to education and work, as well as increases in productivity on a local, national and international scale.

But we also need to make sure that the actions we take are sustainable; that humanitarian measures build long-term self-sufficiency in the communities they seek to help, that they meet the needs of a growing global population and minimise the pressure on our planet's resources.

These are set to be the biggest engineering challenges of the next century. It is only by applying the best talent that we can meet all of these challenges and continue to improve quality of life and economic prosperity for generations to come.

The *Engineering a Better World* conference seeks to bring these great engineers and the international development community together to identify how we can best fulfil the SDGs and work to improve the world we live in.

By demonstrating the incredible contribution engineering continues to make in tackling some of the world's biggest problems, we hope to build partnerships that drive progress towards the SDGs, encourage further participation in sustainable development and attract the skills required to ensure this century is even more transformative than the last.

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1 *Global Tracking Framework 2015*, World Bank and International Energy Agency, 2015
2 Estimates from *Progress on sanitation and drinking water – 2015 update and MDG assessment*, UNICEF and WHO, 2015
3 *Global Sustainable Development Report*, United Nations, 2016

Blue Gold ©Khalid Hossain Ayon and Anis Pervez

Keith Howells Chairman, Mott MacDonald

ENGINEERS WILL PLAY A VITAL ROLE IN REALISING THE UN SUSTAINABLE DEVELOPMENT GOALS

The UN Sustainable Development Goals (SDGs) provide a universal framework to tackle the biggest problems facing our planet. From ending world hunger to improving global healthcare, the SDGs seek to shape development policies and investment to deliver the best impact. They go further than the Millennium Development Goals, which expired in 2015, by bringing more focus to the root causes of problems, with added emphasis on human rights and gender equality.

Engineers will play a crucial role in delivering the SDGs. Traditional infrastructure solutions to expand access to clean water or energy, or that make cities function more efficiently can have a huge impact on those who benefit from the service. But today's engineers are required to think beyond hard infrastructure solutions. Increasingly, physical infrastructure needs to be complemented by social infrastructure to realise the most benefit.

One example is Blue Gold, an ongoing project in Bangladesh that Mott MacDonald is supporting. Almost 40% of people living in the southwestern coastal region live below the poverty line and face food and water insecurity. The project aims to alleviate poverty for 150,000 families by enabling communities to play the lead role in identifying, implementing and maintaining solutions: the project's success depends on social as much as physical changes.

Blue Gold has fostered 350 organisations to represent local communities that decide on mutually beneficial water management interventions to protect farmland from river or weather erosion. Women's participation has been enhanced, on-the-ground training has helped farmers diversify their crops or livestock, and support has been given to help villagers bring produce to market.

Such actions enable local people to become self-sufficient and to sustain the programme's positive outcomes when external financial assistance comes to an end.

Altogether, the project makes progress towards four of the SDGs: to reduce poverty (SDG1), to increase food security (SDG2), to improve gender equality (SDG5), and to promote sustainable economic growth (SDG8).

Projects like this, and the many others shown in this brochure, counter the common misconception that engineering is all about pipes and boreholes. Instead, they show clearly the incredible breadth of areas that engineering covers, and the truly transformative impact it can have around the world.

End poverty in all its forms everywhere

TECHNOLOGY JUSTICE FOR THE POOREST AND MOST VULNERABLE

Paul Smith Lomas
CEO
Practical Action

The Sustainable Development Goals (SDGs) will not be reached if we do not address the fundamental technology injustices that leave people behind. Technologies have a critical role to play to achieving an acceptable standard of living for all, addressing multidimensional forms of poverty that are inherent throughout the 17 interdependent SDGs. From essential medicines to maintain health, to safe sanitation systems in rapidly expanding urban areas, technology is at the heart of sustainable development and wellbeing.

The potential of new, innovative technologies to dramatically enhance the wellbeing of people and the planet means that the rules and incentives that guide technological innovation are at the centre of the development challenge. It is vitally important that design and engineering take a user-centred approach and that the innovation and adaptation of technology is based on users' needs.

There is a stark inequality in who shares the benefits and the costs of technology development. Access is unjust and unequal, serving and prioritising those able to afford access to the latest technologies. Not to mention all of the existing technologies that could transform lives today if market systems, political choices and incentives supported technology access for those that need them most.

We need 'technology justice' – where all people are empowered through equitable access to the technologies they need for health and productive livelihoods; where users are involved in the innovation of technologies in their local contexts; and where technology use does not harm our planet, ensuring safe and habitable environments both now and in the future[1].

Technology injustice is no more evident than in the case of energy access. Access to affordable, reliable, clean forms of energy is vital for delivering many other basic services: to enable hospitals to operate equipment and keep vaccines at optimal temperatures; to power irrigation systems to produce food to feed a growing global population; to light houses so that children can study and achieve a basic

Technology injustice is no more evident than in the case of energy access. Access to affordable, reliable, clean forms of energy is vital for delivering many other basic services. To enable hospitals to operate equipment. To power irrigation systems to produce food. To light houses so that children can achieve a basic level of education.

Practical Action

level of education; and to empower women and girls by using communications technologies to advocate for their rights.

A billion people still lack any form of electricity, while a further billion make do with intermittent and poor-quality power supplies[2]. Recent projections suggest that global population growth will mean an increase in the absolute number of people lacking access by 2030[3]. The majority of the energy poor are in areas unlikely to be served by national power grids in the near future[4]. Yet it is more likely that investment in research and development will support shale gas exploration, than technologies that can provide off-grid energy access.

But things can be different. We can reach these two billion people and more within the next decade, ahead of the SDGs' deadlines. Renewable, distributed and democratised energy can leapfrog traditional grid-based

approaches and deliver equitable energy access at a fraction of the cost of traditional grid-based systems[5]. These can empower people through control of their own economic resources, and unlock pathways for achieving the range of SDGs, thus achieving 'technology justice' for all.

In Zimbabwe, Practical Action is working with 15,000 people in rural communities to address their energy needs through affordable, renewable energy technologies. At a time of severe drought, smallholder farmers are able to harness the capacity of solar photo-voltaic cells to power irrigation systems and process and store crops to prevent wastage, feeding communities and generating incomes even in highly challenging conditions. Meanwhile, $46 of economic impact is generated for every $1 invested in one of the 1,250 'Solar Sister' women energy entrepreneurs in Nigeria, Tanzania and Uganda[6].

In Malawi, Practical Action's MEGA project has helped bring energy access to communities in Mulanje through small-scale hydroelectric powered minigrid systems, providing electricity for vital community services including six schools and four health centres serving over 29,000 people. By addressing access, innovation, and sustainability, the three key pillars of 'technology justice', we can empower the poor and vulnerable and achieve each of the 17 SDGs by 2030. But the current innovation system is not working. Without change, it will continue to drive injustice, inequality and catastrophic environmental damage. We must push for a radical overhaul of the incentives and regulation of technology innovation, so that it focuses on the needs of the poor and unserved.

1 http://dx.doi.org/10.3362/9781780446240
2 http://energyaccess.org/wp-content/uploads/2015/07/EAPN-Towards-Achieving-Universal-Energy-Access-by-2030.pdf
3 https://ieg.worldbankgroup.org/blog/electricity-access-challenge
4 http://hystra.com/energy
5 http://policy.practicalaction.org/resources/publications/item/power-for-all-the-energy-access-imperative
6 https://www.solarsister.org/blog/press-release-empowering-women-and-eradicating-energy-poverty-in-africa-schwab-foundation-honors-solar-sister-ceo-katherine-lucey

End hunger, achieve food security and improved nutrition and promote sustainable agriculture

SUSTAINABLE INTENSIFICATION COULD END CHRONIC HUNGER

Sir Gordon Conway KCMG HonFREng FRS
Professor of International Development, Imperial College London

Dr Ousmane Badiane
Director for Africa, International Food Policy Research Institute, Dakar, Senegal

In the developed countries of the world, hunger is a feeling of slight discomfort when a meal is late or missed. By contrast, for some 800 million people – men, women and children – hunger is a daily occurrence, both persistent and widespread.

The majority of the hungry live in South Asia, but the proportion of hungry in sub-Saharan Africa is very high, about a quarter of the population. Most shocking of all are the more than 150 million[1] children under five years old in the world who are so malnourished that they die or grow up stunted, both physically and mentally.

The world as a whole achieved the Millennium Development Goal for halving hunger by 2015 but, in sub-Saharan Africa, only Ghana was successful. Now we have a new Sustainable Development Goal (SDG) that aims to end hunger, achieve food security and improved nutrition and promote sustainable agriculture, by 2030. Can we do it?

We must double food production in developing countries by 2050, and by 70%, globally. We also must greatly increase access to food.

But we have to do this in a sustainable fashion, and engineering and technology are key to ensuring that. We have to more prudently use inputs such as pesticides and fertilisers, be adaptive to climate change, reduce the greenhouse gases from agriculture, build up natural capital such as the quality of our soils, and on top of all this, be resilient. We call this approach 'sustainable intensification'. It's a tall order and developing country farmers need all the help they can get.

One answer lies in precision farming. In the developed countries, tractors, cultivators and harvesters can use GPS (global positioning system) to position themselves to within a few centimetres of a target, to place fertiliser in the right amounts according to need in different parts of a field. This can be appropriate in some of the larger farms in developing countries, but the principles are also relevant for smallholder farmers.

In Africa, farmers use a technique known as microdosing: placing fertiliser in each planting hole using a cap of a soda bottle to deliver a

Better nutrition could be achieved by reducing food waste and loss. Post-harvest losses in cereal production in Africa are 15–20% annually and higher for more nutritious and higher value fruits and vegetables. Improved, but low-cost, household storage and local warehousing would make a significant difference.

small but precise amount. This method produces high yields, saves costs and reduces the nitrous oxide emissions.

Precision use of water is also critical. Irrigation has been a critical driver of agricultural production in Asia. But in sub-Saharan Africa only 4% of the arable land is irrigated. There is room for more large irrigation schemes, but major challenges of funding and management need to be overcome to minimise risks for humans and the environment. Small-scale irrigation has an equally large potential and could reach more people in more places. Small dams can be engineered for each mini-watershed, providing both irrigation water and generating electricity fed into smart micro-grids to drive down the cost of power for rural households.

Soils, too, need more precise management. Severe erosion affects nearly 30% of the global land area, and over 25% of sub-Saharan Africa. Part of the answer lies in carefully contoured terraces, in the application of mulches expressly designed for each mini-watershed, and in

appropriate cultivation using forms of the two-wheel tractors so widespread in Southeast Asia.

Better nutrition could be achieved by reducing food waste and loss. Post-harvest losses in cereal production in Africa are 15–20% annually and higher for more nutritious and higher value fruits and vegetables. Improved, but low-cost, household storage and local warehousing would make a significant difference.

Finally, a crucial element is the role of digital technology. Many smallholder farmers live far from cities and towns and are often poorly served by all-weather roads. Digital technology can help overcome, in a shorter time and at lower cost, many of the infrastructural and institutional obstacles that traditionally prevent smallholder farmers accessing established markets.

Today, 75% of Africans own mobile phones; the ubiquity and rate of interconnections are similar to those seen in more developed parts of the world. It is this extent and speed

of interconnection that can both accelerate agricultural transformation in the developing world and help deal with the complex challenges of establishing a 21st-century food and nutrition security system.

Doubling food production in developing countries by 2050 might seem impossible, but we have the technologies to achieve it. From simple farming techniques such as microdosing, to GPS and mobile technology, applying new innovations and methods at the small scale can have a significant impact on food production in developing nations. By focusing on 'sustainable intensification', we can ensure that the progress we make will feed the world in many generations' time, not just today.

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1 Global Nutrition Report 2016, http://globalnutritionreport.org/the-report/

Ensure healthy lives and promote well-being for all at all ages

IMPROVING ACCESS TO HEALTHCARE SERVICES THROUGH TECHNOLOGY

Ashir Ahmed

Director
Global Communication Center
Grameen Communications, Bangladesh

Associate Professor
Faculty of Information Science and
Electrical Engineering
Kyushu University, Japan

One billion people (15% of the world's population) don't have access to quality healthcare services. Most of these people are from rural areas in developing countries. Healthcare services do not exist there for two major reasons: doctors do not want to stay in villages as they do not find their livelihood requirements fulfilled, or quality clinics lack a stable income and the government does not have enough funds to build and run clinics.

The developed world is facing a different situation. It will soon have more old people than children and more people at extreme old age than ever before. In Japan, it is expected that by 2030, one in every three people will be over 65 years old. The transition will impact on long-term healthcare systems and local community support systems, and will change the social structure as a large percentage of elderly people live alone or with a spouse.

To accommodate the social cost of hard to reach communities and an ageing society, there is a strong need for affordable primary and preventative care. In particular, there is a need for healthcare delivery models that are less reliant on doctors and more on other health workers that can reach people in remote locations. Engineering solutions are key to empowering local health workers to provide accessible, quality healthcare. The rise of information and communication technologies in particular has opened up access to advanced medical knowledge from afar.

Grameen Communications in Bangladesh and Kyushu University in Japan have developed the Portable Health Clinic (PHC), a compact telehealth system that seeks to reach remote communities with quality healthcare. The portable clinic, which resembles a briefcase, contains diagnostic equipment and software for archiving and searching patients' past health records that can be operated by health workers. A health worker in a community can visit patients and take clinical measurements using the diagnostic tools in the PHC briefcase. They will insert the measured data by using an app on a tablet PC, and upload the measured data to a database. A simple algorithm is then

Engineering solutions are key to empowering local health workers to provide accessible, quality healthcare.

used to categorise the patients in four different colors: green (healthy), yellow (caution), orange (affected), and red (emergency).

In order to secure urgent treatment for those most in need, the healthworker sets up a remote session for orange and red patients using mobile network coverage to connect them to a medical call centre. Doctors access the electronic results of the health check-up and provide advice for the disease and an e-prescription. The health worker prints the prescription, and explains the medication procedures in a patient-friendly language to the patients. This way, the portable health clinic can offer all the features of a traditional clinic.

With any technology developed to be accessible, the key design requirements are to be low cost and easily transportable. The PHC briefcase will cost less than $300 and be light enough to be easily carried.

So far, we have completed a trial project with experiments in 32 remote locations in Bangladesh, by collaborating with local organisations to observe the local adoption of the technology. The objective was to identity low income people at risk and improve their medical condition. In the first large group health check-up, 8,527 patients were medically screened, with 1,629 patients identified as high risk and the same amount of patient-doctor telehealth consultancies established (orange 1,450 and red 179). The high-risk patients were prescribed medicine and a follow-up health check-up was scheduled for two months later.

In the follow-up, 61% of the original high-risk patients were re-examined using the same procedure. The measurements showed a remarkable improvement: 481 (48%) orange patients had moved to the yellow category and 70 (7%) patients had moved to the green zone. The results for 2013 also showed a marked decrease in non-communicable morbidity.

It's clear that applying engineering solutions to healthcare can drastically improve access for communities that previously had no access to healthcare provision, and we envisage that the PHC model can be replicated in other countries.

Challenges do still remain. Handling of private data over risky internet connections and the prevalence of errors in medical records need to be detected and fixed at source. However, technologies such as artificial intelligence and improved internet capability will continue to open up new opportunities to improve and implement remote healthcare. With time, algorithms like ours will be improved by considering age, gender and properties of the local environment to provide tailored care. If we get it right, the result could be fairer and more equal healthcare for everyone, irrespective of location, age or wealth.

Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

IMPROVING LIVES THROUGH THE ADVANCEMENT OF LEARNING

Jan Kowal

Programme Director
Department of Engineering and
Innovation at the Open University

Until fairly recently, it was assumed to be essential in the teaching of engineering that the students come to a laboratory to do their practical experiments. However, with engineering advances like the arrival of the World Wide Web, this approach is being challenged by the use of digital media. Students have already for some time been using software simulations, viewing audio-visual content, taking part in online conferencing, and inhabiting web spaces in which to collaborate on projects and share and comment on each other's work. But there is further to go, and educators everywhere are continually seeking to improve and extend the world of online learning. For the first time, it is possible to offer students practical learning experiences online that are as rich as if they had the equipment in front of them.

The possibilities of such advancement are vast, and directly feed into the UN's fourth Sustainable Development Goal (SDG 4): to ensure inclusive and equitable quality education and promote lifelong learning opportunities for

all. As well as making education more convenient for those who already have access to it, it is now a possibility for many more people for whom it was previously unreachable. People in remote areas now have access to the best quality education, and those who have no choice but to work can now fit it in around their other commitments.

At the Open University (OU), our mission is 'to be open to people, places, methods and ideas' and promote educational opportunity and social justice by providing high-quality university education to all who wish to realise their ambitions and fulfil their potential. We have been implementing further technical advances, to add more and more functionality to remote learning. This has been particularly beneficial for our engineering students, to ensure that they have the practical skills needed to really make a difference in the real world. The OpenSTEM lab is a multimillion pound project to bring real experiments to students on a massive scale. Using racks of web-linked electromechanical systems and associated measurement instrumentation and webcams, students will

> We need to ensure that a holistic view is taken in regards to education – from primary school upwards.

© Kit Oates

be able to log onto the system at a time convenient for them to operate the equipment, take measurements and share their results as if they were physically present at the lab bench.

The aim behind this is to help students gain as good a 'feel' for working on real engineering systems at their remote locations as their fellow students at conventional universities. Although it is possible to study engineering entirely through reading theory and using mathematical tools, the best way to gain insight into whether a proposed engineering solution is likely to work is through practical experience of, and experimentation with, how tangible things behave.

We expect to extend the use of the OpenSTEM lab such that students using our MOOCs (massive online open courses, which are available free of charge to anyone in the world with an internet connection) also have the opportunity to perform and learn from real experiments. MOOCs are an important part of the formal online learning, but there is an additional intermediate step, in the form of providing assessment that

the student can complete and have marked. Students who have shown that they have learnt enough from the online module then receive a digital badge that is uniquely identifiable as belonging to them and can be used as evidence of attainment. We hope in this way to create an even smoother progression path from informal to formal learning.

We also need to ensure that a holistic view is taken in regards to education – from primary school upwards. Even in the UK, the primary and early secondary education stage has been recognised[1] as a weak point within a 'leaky pipeline' and is a serious problem that is progressively worsening the shortage of educated engineering professionals.

For this reason, OU initiatives to create open educational resources for primary and secondary teacher education in sub-Saharan Africa and more recently in India (TESSA and TESS-India) are important foundations for the building of a complete infrastructure for the education of engineers in both these parts of the world.

Engineering skills are vital to the creation of a workforce that will develop the infrastructure that can improve lives and address global issues such as secure settlements and reliable sanitation. Improving engineering education and making sure our future engineers are of the best calibre has the potential to have a global impact. We already have the technology to effectively foster those skills, and improve access to quality education for all. Who knows what incredible innovations these new practical skills will create?

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1 *Perkins Review of Engineering Skills* (2013), BIS, London

Achieve gender quality and empower all women and girls

EMPOWERING WOMEN TO REACH SOCIETY'S FULL POTENTIAL

Yassmin Abdel-Magied
Author of *Yassmin's Story*
Founder
Youth Without Borders

Imagine a new men's toilet block being commissioned for your local sports club. The old toilet facilities have fallen into disrepair, and the governing council of the club announces it is time for a refurbishment. The governing council of this sporting club also happens to be all women.

When it comes to confirming the design of facilities, it is unanimously agreed that they will be exactly the same as the newly designed women's facilities. Those facilities, the council reasoned, had come out quite nicely. 'Everyone' was pleased with the result.

The men in the club were uncomfortable with the outcome but were told by the governing council that their perspectives had been taken into account. Even though no men had been involved in the decision-making process, they were told this was the best solution for all.

Now, that does not make sense, you might think. Why would a group of women decide on the design of facilities on behalf of the men? How could they do that without even properly consulting them?

Of course it doesn't make sense. That is the point.

The above scenario would almost never occur in real life because often, the reality is in fact the opposite. It's not just with infrastructure projects – this is the way decisions are made for and about women living in almost every society, every day. Choices that directly and indirectly affect women's lives – whether as obvious as a toilet block design or as obscure as the lighting at public transport stops – are often made without women's involvement, and as such, the outcomes are often unfit for purpose. At the very best, they silently marginalise the community they are meant to serve. To combat this and make the resulting infrastructure fit for purpose, engineers need to ensure that they have input from all sections of the community they are serving.

This is one of the reasons why the UN's fifth Sustainable Development Goal (SDG 5), to achieve gender equality and empower all women and girls, is incredibly important. Full and effective participation of women in both

The World Economic Forum's *Global Gender Gap Report* shows that for many countries, raising women's workforce participation to the same level as men's could raise GDP per capita by significant amounts – in Egypt for example, by 34%.

engineering projects as well as in leadership roles – and equal opportunity across the board: political, economic and social – is imperative to an optimally functional and cohesive society. One of the reasons, but not the only one.

Full and effective participation is not only about ensuring societies' infrastructure is designed in a way that is fit for purpose. Like many teams, the whole becomes more than the sum of the parts. When women are empowered and have access to participation and leadership, all of society benefits, and some of these benefits we should not do without.

The statistics speak for themselves.

The International Labour Organisation suggests that women's work may 'be the single most important factor in reducing poverty in developing economies'.

Christian C. Dezsö and David Gaddis Ross argued in 2011 that firms with females at the senior executive level added $44 million to the company's value.

The World Economic Forum's *Global Gender Gap Report* shows that for many countries, raising women's workforce participation to the same level as men's could raise GDP (gross domestic product) per capita by significant amounts – in Egypt for example, by 34%.

The book, *Sex and World Peace*[1], suggests that the 'very best indicator and predictor of a state's peacefulness is not wealth, military expenditures or religion, but how well its girls and women are treated'. The book goes on to argue, using 148,000 data points over 375 variables for 175 countries, that 'the full and complete development of a country, the welfare of the world and the cause of peace require the maximum participation of women on equal terms with men in all fields'.

So not only does full and effective participation of women in leadership mean better suited and more sustainable infrastructure, which will arguably lead to safer and more inclusive communities, it will also be economically

and politically beneficial for countries across the board.

Men and women may have differing ways of engaging with leadership, different leadership styles and may want different types of opportunities. The question is not about how the opportunity looks or presents itself, but that it truly exists in the first place.

At the end of the day, roughly half the population is made up of women, or those who identify as women. Society simply cannot function at its full potential if only half the talent is being utilised. It is incumbent upon us that we allow every possible opportunity for the other half of the talent to participate and to lead. Together, we can work towards a world that looks after us all.

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1 *Sex and World Peace*, Valerie Hudson, Bonnie Ballif-spanvill, Mary Caprioli and Chad Emmett, 2014

Ensure availability and sustainable management of water and sanitation for all

HARNESSING DATA TO DELIVER WATER AND SANITATION TO ALL

Barbara Frost
Chief Executive
WaterAid

Last autumn, global leaders gathered to agree a set of promises that would end extreme poverty and create a fairer, more sustainable world within 15 years.

Now the clock is ticking. Ensuring that the sixth Sustainable Development Goal (SDG 6), achieving universal access to clean water and sanitation by 2030, is met will require a fundamental change in how we all work; WaterAid and our partners are focusing our efforts on this goal.

It is a massive challenge: more than 650 million people don't have access to clean water and more than 2.3 billion – one in three people – don't have access to a decent toilet. The result is hundreds of thousands of hours lost to long, dangerous journeys to collect water, illness and reduced productivity. Worst of all, 315,000 children under five die because of preventable diarrhoeal illnesses linked to dirty water and poor sanitation every single year.

In addressing such a complex global problem, data will play an integral role.

Drilling boreholes and building the taps and toilets isn't enough; what's essential is ensuring that this infrastructure is well planned, managed and maintained.

In developed countries, this generally happens through water utilities that employ inspectors, engineers and technicians and regulation to ensure quality and a fair pricing structure. This is the ultimate goal in developing countries as well. However, local and national governments need purposeful leadership and support to get there. Monitoring of water and sanitation services, and collecting data on which areas are served, how they are operating and which areas are still without, are key components of these efforts.

The opportunities to improve this data management are ever increasing in a digitally connected world. For two years, WaterAid has been bringing its experience to the development of an easy-to-use digital monitoring platform, mWater[1], to map and monitor water access using mobile technology. It allows us to conduct mobile surveys, and to share and analyse real-time data
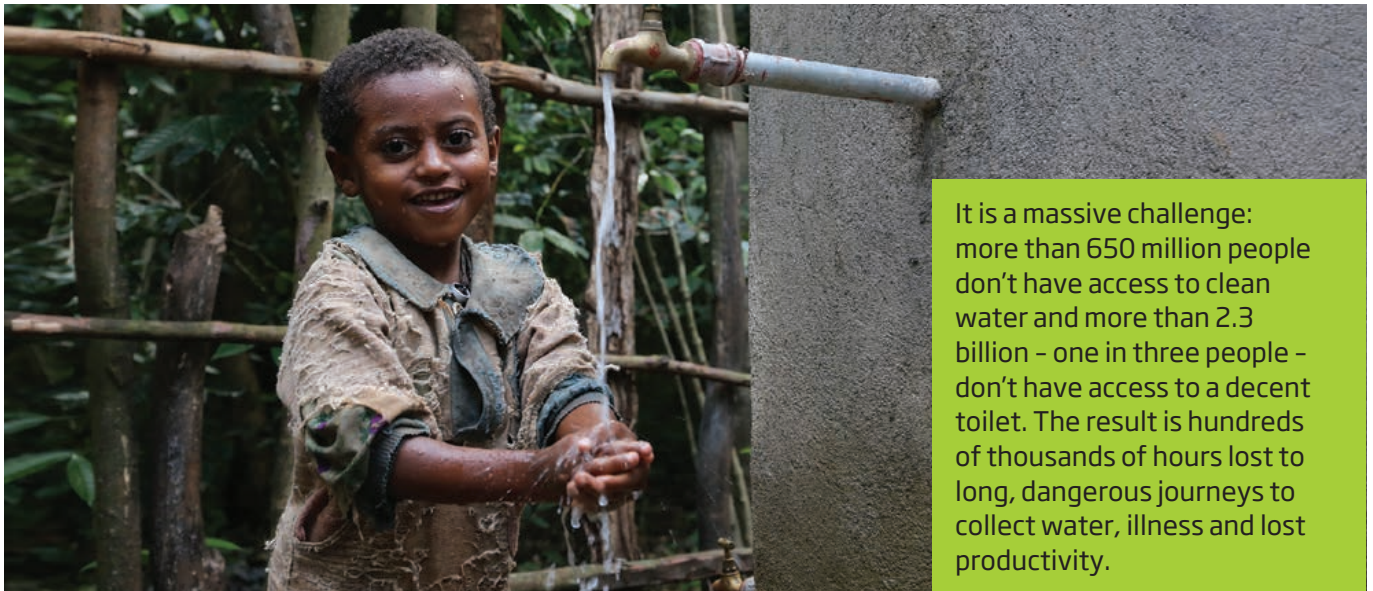
It is a massive challenge: more than 650 million people don't have access to clean water and more than 2.3 billion – one in three people – don't have access to a decent toilet. The result is hundreds of thousands of hours lost to long, dangerous journeys to collect water, illness and lost productivity.

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across organisations. The mobile apps work both off- and online, so that data can be logged even in remote locations where the internet is unreliable or unavailable.

More than 4,000 non-governmental organisations, governments and research users are currently mapping and monitoring global water data with mWater. Over 350,000 sites have been mapped across some 59 countries and this is increasing rapidly.

In Bangladesh, for example, a sustainability survey in December 2014 included visits to more than 1,200 communities. Using mWater instead of pen and paper allowed it to be completed more quickly and efficiently, without the errors that come with recording information manually.

This isn't just about data gathering. What's important is getting quality information and putting it to use and empowering communities to advocate for change. Common information platforms allow for the development of common standards that can then be incorporated into national governments' objectives on water and sanitation systems.

Ultimately, delivering water and sanitation to everyone, everywhere, means that national and district governments need to lead the way, by making water and sanitation infrastructure and programming a priority, and financing it accordingly. Strong data helps illustrate the need, allowing governments to, for example, know whether water points are working, if they are providing enough clean water, when they break down and how long the wait is for repair, if they are being repaired at all.

Pooling this data across communities, districts, countries and internationally will be key to ensuring that SDG 6 is met, in part by ensuring that alongside reaching new people with water and sanitation, those communities already reached are not falling behind.

Reaching everyone, everywhere – including in remote rural locations and the poorest and most marginalised – requires strong systems for monitoring and evaluation as well as affordable, appropriate and accessible technology and systems. You cannot deliver a service if you don't know where it is most needed; you cannot repair

something that is broken if you do not know that it has ceased to function.

There are still challenges to overcome, including technical barriers when systems can't talk to each other, and organisations or governments that might be reluctant to share data or to take leadership on these issues. But data collection from a range of sources and knowledge-sharing will be key to helping countries create, strengthen and maintain the systems required for permanent water and sanitation services. When communities and those supporting them know who is being reached, and for how long, then service providers are better equipped to reach those without.

Reaching everyone, everywhere with water, sanitation and hygiene by 2030 requires a major shift in political will and prioritisation, investment in human resources, regulation and systems, and reliable information collected and shared to ensure accountability.

1 www.mwater.co/

Ensure access to affordable, reliable, sustainable and modern energy for all

UNIVERSAL ENERGY ACCESS: GOING FURTHER, FASTER, AND AT LOWER COST

Sam Parker

Director
Shell Foundation

There are many levels of energy access. Indeed, the UN has identified five 'tiers' of energy access, running from task lighting and mobile phone charging (Tier 1), to the addition of fans, radios and TVs (Tier 2), to very high power for agro-processing appliances and machinery (Tier 5).

My view is that the seventh UN Sustainable Development Goal (SDG 7), to achieve universal access to affordable modern energy by 2030, is eminently achievable for Tier 1. Tier 2 is also achievable, with the right conditions. Yet building a global market to achieve higher levels of energy access (Tiers 3 to 5 and beyond) for low-income consumers is a greater and more complex challenge, especially in rural areas.

250 million households worldwide still lack Tier 1 energy, without which there is little prospect of people escaping poverty. The good news is that advances in engineering and business innovation mean that enterprises can now offer Tier 1 energy on a viable basis, including entry-level solar lights for as little as $5. At least 40 million solar lighting products have now been

sold across Africa and Asia. Bloomberg New Energy Finance forecasts that, with modest investment and the right government support[1], close to 100 million low-income households could access off-grid solar before 2020.

The transformative impact of these pioneers in providing access to Tier 1 energy is too often played down. Stay in any of the thousands of villages where the day finishes at sundown, and you will appreciate what it means to have three more hours in the evening with proper light to read, study, cook and see the faces of your family.

Inspired by the emergence of Tier 2 energy pioneers offering solar home systems, the African Development Bank announced a new goal in summer 2016 to ensure 75 million off-grid households in Africa have access to Tier 2 energy by 2025. By our estimates, this will cost at least $15 billion, or $1.6 billion investment per year. The business models for Tiers 1 and 2 energy provision have been substantially proven and the market de-risked. What is needed now is growth finance to achieve scale.

Stay in any of the thousands of villages where the day finishes at sundown, and you will appreciate what it means to have three more hours in the evening with proper light to read, study, cook and see the faces of your family.

Shopkeeper © d.light

$1.6 billion per year is not expensive. Investment in grid infrastructure is set to be $66 billion each year and Africans already spend $14 billion per year on unreliable and expensive energy. Nevertheless, we will not achieve SDG 7 unless we figure out how to mobilise this $15 billion.

New and exciting models, such as mini-grids and solar-diesel hybrid rental farms, are also emerging to provide access to Tier 5 energy and above, where 24/7 power supports agro-processing, community services and SMEs (small- and medium-sized enterprises). This is where deeper economic growth starts. These rural infrastructure businesses will require greater capital but will deliver superior service.

So, the solutions exist and will continue to improve. As an independent charity, Shell Foundation has spent the last decade supporting energy enterprises to find new ways to serve low-income consumers and we know there are no shortcuts. Like any other business, off-grid energy pioneers need the resources to do the 'heavy lifting' of building

teams, systems, sales force and supply chains. They also need the right market conditions to accelerate growth.

The money is there, but for the most part, not in a form that is accessible to young enterprises. We now dedicate a significant proportion of our resources to testing new financial instruments designed to leverage investment by blending capital and offsetting risk.

Nascent energy enterprises are calling for clear tax regimes, supportive regulation, mobile payment infrastructure and standards to protect consumers. They need consumers who aware of the benefits of modern energy and they need the freedom to move skilled staff between countries to share know how.

Under these conditions we could achieve SDG 7 well before 2030. That is what consumers are asking for and what governments want.

Foundations must play their part. We have access to risk tolerant capital to kickstart innovation, validate new technologies and build

investor confidence. We can help demonstrate the potential of off-grid energy provision to governments. Once we do, resources will follow. If decentralised energy could service, say, a third of consumers in a country, why would it not warrant at least 10% of a country's annual energy expenditure?

Shell Foundation will spend over half of its annual operating budget on energy access over the next five years, as we seek to support innovative engineering projects and build a strong enabling environment for 'energy access' markets to thrive. Our charity has a rare resource, and we must now optimise this by aligning closely with governments, investors, NGOs (non-governmental organisations) and corporates to take this once in a lifetime opportunity. When we look back in 2030, I hope we can all say we used our time and effort well.

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1 http://about.bnef.com/white-papers/off-grid-solar-market-trends-report-2016/

Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

THE CONTRADICTIONS OF ECONOMIC GROWTH IN AN ERA OF ECOLOGICAL LIMITS

Dr Jason Hickel
Professor of Anthropology
London School of Economics

What is so refreshing about the UN Sustainable Development Goals (SDGs) is that they recognise the inherent tension between economic development and the ecology of our planet. The preamble affirms that 'planet Earth and its ecosystems are our home' and underscores the necessity of achieving 'harmony with nature.' It commits to holding global warming below 2°C, and calls for 'sustainable patterns of production and consumption'.

This language signals awareness that something about our economic system has gone terribly awry – that we cannot continue chewing through the living planet without gravely endangering our security and prosperity, and indeed the future viability of our species.

However, the core of the SDG programme relies on the old model of indefinite economic growth that caused our ecological crisis in the first place – ever-increasing levels of extraction, production, and consumption. SDG 8 calls for 'at least 7% GDP growth per annum in the least developed countries' and 'higher levels of economic productivity' across the board. In other words, there is a profound contradiction at the heart of the SDGs. They call for both less and more at the same time.

This call for more growth comes at an odd time – just as we are learning that it is not physically possible. Currently, global production and consumption levels are overshooting our planet's biocapacity by about 50% each year[1]. In other words, growth isn't an option any more – we've already grown too much. Scientists tell us that we are blowing past planetary boundaries at breakneck speed and witnessing the greatest mass extinction of species in more than 66 million years.[2]

The hard truth is that our ecological overshoot is due almost entirely to overconsumption in rich countries, particularly the West.

SDG 8 calls for improving 'global resource efficiency' and 'decoupling economic growth from environmental degradation'. However, global material extraction and consumption has in fact doubled over the past 30 years, and accelerated since 2000[3]. Current projections show that by 2040 we will more than double the

Currently, global production and consumption levels are overshooting our planet's biocapacity by about 50% each year.

world's shipping, trucking and air miles – along with all the stuff those vehicles transport[4]. Our tropical forests are set to disappear by 2050[5]. By 2100, we will be producing three times more solid waste than we do today[6].

Efficiency improvements are not going to cut it. Yes, GDP growth is still necessary in poorer countries; but for the world as a whole, the only option is intentional de-growth and a rapid shift to what Herman Daly called a 'steady-state' economy that maintains material throughput at ecological equilibrium[7].

De-growth does not mean poverty. On the contrary, de-growth is perfectly compatible with high levels of human development[8]. It is entirely possible for us to shrink our resource consumption while increasing things that really matter: human happiness, wellbeing, education, health, and longevity. This is the end toward which we should apply our finest

engineering minds and the development of new technologies. Indeed, the surer route to poverty is to continue on our present trajectory, for, as Joseph Stigltiz said, in a world of ecological overshoot, GDP growth is diminishing living standards rather than improving them[9].

We need to abandon GDP in favour of a saner measure of human progress, such as the genuine progress indicator, which assesses how citizens are progressing socially and economically. However, the SDGs pass this urgent challenge down to the next generation - at the bottom of SDG 17 it states: "by 2030 build on existing initiatives to develop measurements of progress on sustainable development that complement GDP." In other words, they shelve the problem until 2029.

But what of employment? After all, that is what the rest of SDG 8 focuses on. To the extent that de-growth requires eliminating unnecessary

production and work, we need to think seriously about that other big idea that has captured public imagination over the past couple of years: a universal basic income. How to fund it? There are many options, including progressive taxes on commercial land use, financial transactions, foreign currency transactions and capital gains.

Let's face it, in an age of rapid automation, full employment on a global scale is a pipe dream anyhow. It's time we think of ways to facilitate reliable livelihoods in the absence of formal employment. Not only will this assist us towards necessary de-growth, but also allow people to escape exploitative labour arrangements and incentivise employers to improve working conditions – two aims that SDG 8 pursues. What's more, it will allow people to invest more of their time and effort into things that matter: caring for their loved ones, growing their own food, nourishing communities, and rebuilding degraded environments.

1 National Footprint Accounts, Global Footprint Network, 2016
2 *Planetary Boundaries: Guiding Human Development on a Changing Planet,* Will Steffen et al., 2015
3 *Global Patterns of Material Flows and their Socio-Economic and Environmental Implications,* Stefan Giljum et al., 2014
4 Bernstein research, as reported in *Business Insider,* 2016
5 John Mongilloand Linda Zierdt-Warshaw, 2000
6 Environment: *Waste Production Must Peak this Century,* Daniel Hoornweg, et al., 2013
7 *From Uneconomic Growth to a Steady State Economy,* Herman Daly, 2014
8 *The Proximity of Nations to a Socially Sustainable Steady-State Economy,* Daniel O'Neill, 2015
9 *The Great GDP Swindle,* Joseph Stiglitz, 2013

Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation

WAKE UP TO DATA INFRASTRUCTURE

Professor Sir Nigel Shadbolt FREng

Principal and Professorial Research Fellow in Computer Science
Jesus College, University of Oxford

Gavin Starks
CEO, Open Data Institute

Human societies change when resources become either plentiful or scarce. The agrarian revolution saw food become available at a scale, and with a reliability, never seen before. The industrial revolution saw manufactured goods become available at levels and costs not previously seen. We are now in the midst of a data revolution. Data is following the same path as food and manufactured goods before it.

Data is not like food or manufactured goods, however. Those resources are rivalrous. If you consume them or buy them then they are no longer available to anyone else. One of the greatest challenges of the modern world is how to distribute resources equitably and use them sustainably.

When we build our infrastructures for the 21st century – energy and transport, housing and agriculture – we worry about how we will afford them, make them available and do so in a way that does not diminish resources for future generations. The data revolution does not play by these rules. At the Open Data Institute (ODI), we have been working to promote the use of

data at web-scale to support open innovation, providing knowledge for everyone.

Data does not have to be a rival good. Your possession of it does not detract from my possession of it. If you use it then it does not become unusable by me. Of course, we can set up payment and protection systems around data and we must protect people's privacy. But at the ODI, we have been showing the benefits of a data infrastructure that is as open as possible. Certain data has maximal use and value the more widely it is shared and used. Data is a new class of public infrastructure for the 21st century. It is all around us and easy to miss. We need to view it as an infrastructure that is as fundamental to modern society as power and transport, and that requires investment, curation and protection. Data is an infrastructure that, engineered correctly, can generate extraordinary amounts of economic value.

When the human genome was first sequenced in 2000 there was a race to patent that data. In fact it took a 2013 judgement of the US Supreme Court to rule that the genome could not be patented. The value that has accrued from that

Specific sectors have their own infrastructural needs. Health needs lists of hospitals, surgeries, practitioners and procedures. Transport needs rail and bus stations, airports, timetables, fares and real-time travel information. Democracy needs lists of elections, results, candidates and places where people can vote.

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decision[1] has eclipsed a monopolistic assignment of genomic data to a particular organisation. When Transport for London (TfL) made its transport data openly available in 2010[2], it had a transformational impact on the data ecosystem – a flowering of apps and companies using that data to provide services that we all use as we get around one of the great cities of the world more efficiently. Those apps and companies now form part of a global market as transport services around the world open up their data to a common standard. Moreover, TfL calculated that its decision had a return of investment of 58:1[3]. These examples demonstrate that open data generates huge economic returns.

We believe that part of the duty of a modern state is to provide open data infrastructure and promote open standards to make them globally interoperable. We are beginning to see in the open data initiatives around the world what this common public data infrastructure might look like.

Geospatial data, such as administration regions, maps and addresses, are a vital building block for open data infrastructure. Everything happens somewhere. Lists of legal entities (both public and private sector), company directors and beneficial ownership registers help us link data together and understand which organisation is responsible for particular activities. Meanwhile, specific sectors have their own infrastructural needs. Health needs lists of hospitals, surgeries, practitioners and procedures. Transport needs rail and bus stations, airports, timetables, fares and real-time travel information. Democracy needs lists of elections, results, candidates and places where people can vote. In each case both research and experience show us that to maximise value the data infrastructure must be open and used by as many people as possible.

Data infrastructure is an asset that needs to be invested in. It needs to be curated to make sure that the data is as up-to-date and accurate as needed. Data needs to be protected from abuse

by bad actors and, in many cases, recognised as critical national infrastructure. It needs to be designed for openness and the global web of data. We need to encourage agility and open innovation in both how the data is maintained and how it's used. An effective, efficient and equitable data infrastructure will generate value for this and succeeding generations.

1 http://www.gov.scot/Publications/2013/12/6550/4
2 http://content.tfl.gov.uk/item04-ecpp-oct-10-digital-strategy.pdf
3 http://www.gov.scot/Publications/2013/12/6550/4

Reduce inequality within and among countries

ENGINEERS AND ENTREPRENEURS HOLD THE KEY TO REDUCING INEQUALITY

The Right Honourable The Lord Mark Malloch-Brown KCMG PC

Former UK government minister and United Nations Deputy Secretary-General

Inequality almost did not make it into the 2015 UN Sustainable Development Goals (SDGs). The earlier Millennium Development Goals had stopped at poverty reduction – deemed a safer, less controversial objective. In the early stages of drafting the SDGs there was still reticence in some quarters; a fear it was a divisive issue. But, in the last few years, inequality has raced up the political agenda. It's no longer just about the injustice of very poor countries with rapacious ruling elites. It's suddenly about all of us. Whether it was the UK referendum vote on leaving the EU, the US presidential campaign or indeed politics everywhere and anywhere, the division between those at the top and those whose incomes have fallen and stagnated has become the organising force of politics.

So SDG 10, which almost didn't make it, is now as central to development as the fight against absolute poverty was when I and others drafted the original goals. But if there is wide agreement that inequality now poses a direct threat to the stability and health of societies, there is less agreement about what to do about it.

The classic European policy response is to use the redistributive power of taxation. Tax high-income earners and recycle this in the form of social services such as health and education, welfare and income support to the less well off.

Obviously, even in Europe, the effectiveness of this is disputed. It did not, for example, stop a Brexit vote. In much of the developing world, it is anyway a non-starter because the proportion of GDP gathered in tax is much smaller and the inequality gap much wider. There simply aren't the resources available to redistribute.

Nor does it get to the core of the inequality, which is not actually about unequal earnings so much as it is about the division of so many developing countries into modern and traditional economic sectors. In the first, an urban elite accumulates savings, enjoys a western lifestyle with all the trappings and captures most of the benefit of the high economic growth rates that many developing countries have enjoyed in the

It is engineers and entrepreneurs, not tax collectors, who at this stage hold the key to reducing inequality in much of the world. We have to find ways of building inclusive, productive economies on a platform of sustainable energy and infrastructure.

last decade or so. At the same time, most of their fellow citizens eke out a living and remain trapped in either an informal urban sector of marginal employment – slum living and failing infrastructure – or in many places an increasingly inefficient overpopulated agricultural and rural sector.

The real answer to inequality in developing countries is to expand that modern sector: create decent, well-paying jobs off the back of a competitive urban economy of manufacturing, services and a similarly efficient rural sector. For Africa particularly, with the prospect of a doubling of the population in short order, this has become an imperative. By 2025, it too like the rest of the world will have exceeded 50% urbanisation yet there is little sign of jobs and infrastructure keeping up with this prospective demand. The population explosion of cities in South Asia offer a dire warning of the social and human costs when the housing, sanitation and clean water, transportation, let alone the jobs are not there.

So it is engineers and entrepreneurs, not tax collectors, who at this stage hold the key to reducing inequality in much of the world. We have to find ways of building inclusive, productive economies on a platform of sustainable energy and infrastructure. So for now, the key issue is how to leverage and scale-up domestic and international private capital on a scale that matches up to the challenge.

I chair the Business and Sustainable Development Commission, which has assembled a group of business leaders from around the world representing multinationals as well as local SMEs to advocate for the extraordinary opportunity and responsibility that the private sector confronts. Business as usual means mounting inequality, increasing insecurity and environmental and other risks, and a smaller global market as billions of people are left behind in the old economy. On the other hand, finding business models that allow proper financial returns on sustainable infrastructure development and job creation in the developing

world could offer us all a much larger, more prosperous, sustainable and inclusive world. SDG 10's inequality is not a 'nice to have' policy abstraction; rather it will determine all our futures.

Make cities and human settlements inclusive, safe, resilient and sustainable

WHAT ENGINEERS DO IN CITIES WILL SET THE COURSE FOR THE NEXT CENTURY – FOR BETTER OR WORSE

Dr Andrew Steer
President and CEO
World Resources Institute

The battle for a sustainable future will be won or lost in the world's cities. Specifically, how we design, locate, build, and finance urban infrastructure will be the central determinant of the quality of life and health of the planet in the century to come.

This fact was missed in the original Millenium Development Goals (2000 to 2015), when the strong emphasis on poverty meant a focus on rural areas and the emphasis on basic needs led to a focus on health, education and food security, away from infrastructure. As a result many policymakers and aid organisations dropped the ball rather badly in recognising the emerging urban juggernaut. This was costly, and we're now playing catch up.

The pace of urbanisation in the past quarter century has probably been the most dramatic demographic and social shift in human history. In 1990, the urban population stood at two billion[1]. Since then it has doubled to around four billion, as the world's cities have accumulated nearly 100 million extra people each year. In 1900, there were 12 cities in the world with populations over one million. Today, there are

more than 900 such cities and 35 'mega-cities' with more than 10 million inhabitants, and the pace of urbanisation is not slowing. Sub-Saharan Africa, which has been highly rural until recently, is likely to show a dramatic acceleration.

Urbanisation has both responded to, and generated, economic progress. It has helped reduce poverty at a faster rate than ever before, and provided economic opportunities to enable nearly 70 million people each year to enter the global middle class.

Urbanisation is therefore a largely positive transition. So, what's the problem?

Most obviously, governments simply can't keep up with the growth of demand for services. We are underinvesting in new urban infrastructure[2] by around $1 trillion a year. As a result, the quality of transport, power, water, sanitation, and pollution control is weak, leading to unhealthy and inefficient cities. Something more profound is also happening. For most of the past century, cities have been designed for automobiles rather than people. When city populations were modest this worked rather

The Global Commission on the Economy and Climate has shown that smartly designed cities can emit 80% less carbon while being more competitive and enjoying higher income. (Barcelona has a larger population than Atlanta, yet emits only one tenth of the greenhouse gases from transport.)

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well, and suburban life became the aspiration of the middle class; but as cities grow, negative tipping points can be crossed as congestion rises exponentially, imposing a serious drag on a city's economy. In the US, the cost of such 'sprawl' is estimated to have topped $1 trillion per year. In many cities such congestion drags down city income by 10%, and associated pollution can cost another 5–10%[3]. The cost in terms of greenhouse gas emissions is vast.

The good news is that there is a better way. We now know that compact, connected and coordinated cities, in which high-density, mixed-use development is linked to public transport corridors, can lead to a better economy, environment and society. The Global Commission on the Economy and Climate[4] has shown that smartly designed cities can emit 80% less carbon while being more competitive and enjoying higher income. (Barcelona has a larger population than Atlanta, yet emits

only one tenth of the greenhouse gases from transport.) But designing cities around people rather than automobiles could save $3 trillion in infrastructure costs in the coming 15 years.

The upcoming *World Resources Report*[5] will show that policies aimed at making a city more equal will also make it more productive and more environmentally sustainable. Cities where public expenditure is allocated to ensure access to urban services for all segments of the population – particularly the poor and lower middle classes – can lead to a better economy, better environment and better society.

It is these issues that the UN's 11th Sustainable Development Goal (SDG 11) addresses. Already a movement to forge a different urban future is gaining momentum. In India, Prime Minister Modi has committed to creating 100 'smart cities'. Chinese authorities have committed to invest in 100 low carbon cities (seeing carbon emissions

as a proxy for economic inefficiency), and more than 425 cities have signed on to the Compact of Mayors – a commitment by city leaders globally to the proposition that low carbon cities will promote better services and a better economy.

The stakes are very high. Infrastructure decisions made in the next two decades will lock in the trajectory for billions of people for the coming century. It's not too late to get it right – two thirds of the infrastructure that will exist in 2050 in developing countries is not yet built – but the window of opportunity is closing fast. Engineers must join the cause!

1   United Nations, World Urbanization Prospects, https://esa.un.org/unpd/wup/Publications/Files/WUP2014-Report.pdf
2   World Resources Institute, 2014, http://www.wri.org/publication/trillion-dollar-question
3   *New Climate Economy* report, 2014, http://newclimateeconomy.report/2014/
4   Major coalition launched to make economic case for better cities, 2016, http://newclimateeconomy.net/content/release-major-coalition-launched-make-economic-case-better-cities
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THE BUSINESS CASE FOR SUSTAINABLE PRODUCTION

Paul Polman
CEO
Unilever

The agreement forged at the 2015 UN Climate Change Conference (COP21) marked a turning point for humanity and the planet. Signed by 175 nations, it provided for the first time a global framework for tackling the irreversible impacts of climate change. It was also the first test of the UN Sustainable Development Goals (SDGs), which have given us the opportunity to pursue a more sustainable and equitable future.

We need them now more than ever. Fifteen of the last 16 years were the hottest on record, in what climate scientists have signalled 'a climate emergency[1]'. Research by the London School of Economics has shown that inaction on climate change could cost us 17% of the world's assets – or $24 trillion[2]. We need to move from linear consumption and production patterns to a completely different way of looking at things.

This concept lies at the heart of SDG 12, to ensure sustainable consumption and production patterns. As with all of the SDGs, achieving it will require action from business. After all, in developing countries, business represents 60% of the GDP, 80% of the financial flow and

90% of the job creation. But more than that, tremendous opportunities exist for those who are willing to take action. For example, reducing waste that goes to landfill represents a £3.2 trillion market; currently we only recover 20% of that value[3]. With global spending on responsible consumption products increasing year on year – currently at $400 billion[4] – it is clear that consumers are prepared to support sustainable businesses.

At Unilever, we know we have the means to help drive change, with our products reaching two billion consumers worldwide every day. So our response was to build an entirely new business model, the Unilever Sustainable Living Plan (USLP). Its vision is to decouple growth from our environmental footprint, while having a positive social impact in the communities in which we operate. Indeed, many of our USLP goals mirror the SDGs.

By implementing new engineering measures to drive eco-efficiency across our factory network, for example, we have seen cumulative cost benefits of over €600 million since 2008 and our CO_2 emissions from energy are one million

By implementing new engineering measures to drive eco-efficiency across our factory network, we have seen cumulative cost benefits of over €600 million since 2008 and our CO_2 emissions from energy are one million tonnes less per year. We now send zero waste to landfill at over 600 sites in 70 countries; our energy usage has been cut by more than 20% and the amount of renewable energy in our mix has almost doubled.

tonnes less per year. We now send zero waste to landfill at over 600 sites in 70 countries; our energy usage has been cut by more than 20% and the amount of renewable energy in our mix has almost doubled. This is helping us reduce risks from extreme weather and climate change, while contributing to our target of becoming carbon positive in our operations by 2030.

But to make a real and lasting difference, businesses must go beyond what they can achieve in their own operations and infrastructure and commit to redesigning their entire value chain. By building strategic partnerships with like-minded companies, NGOs and governments, companies can bring about transformative change to the broader systems within which they operate. Only then can we hope to help address some of the world's most urgent challenges.

At Unilever, we are focusing on three areas where we have the scale, influence and resources to make a lasting difference:

eliminating deforestation from our value chain, enhancing the livelihoods of smallholder famers, and achieving universal access to safe drinking water, sanitation and hygiene – contributing to SDGs 13, 8 and 6.

On deforestation for example, a major contributor to climate change, we are part of the Consumer Goods Forum – representing over 400 retailers and manufacturers – in an effort to achieve net zero deforestation by 2020. This helped pave the way for the creation of the Tropical Forest Alliance 2020, a global umbrella partnership to reduce the tropical deforestation associated with the sourcing of commodities such as palm oil, soy, beef, and paper and pulp.

Waste is another example where partnerships are critical. Through projects such as the Ellen MacArthur Foundation's Project MainStream – a cross-industry, global initiative – we can help accelerate business-driven innovation and scale the transition to a circular economy. Platforms such as the World Class Manufacturing

Association are driving change by harnessing collective learnings in sustainable operations to realise results that simply could not be achieved alone.

So momentum is building, with an increasing number of businesses living out their commitments to sustainable production. But only by working in cross-sector partnerships, pooling our resources and expertise, can we hope to achieve the ambitions set out in the SDGs. As I reflect on the challenges but also the opportunities that lie ahead, I am reminded by the words of Kenyan environmentalist and activist Wangari Maathai, who argued in her Nobel Lecture:

"In the course of history, there comes a time when humanity is called to shift to a new level of consciousness, to reach a higher moral ground. A time when we have to shed our fear and give hope to each other."

This could be our time.

1 www.theguardian.com/science/2016/mar/14/february-breaks-global-temperature-records-by-shocking-amount
2 *Climate value at risk' of global financial assets,* Simon Dietz, Alex Bowen, Charlie Dixon & Philip Gradwell
3 *Towards the Circular Economy,* Ellen MacArthur Foundation
4 *An Imperative for Consumer Companies to Go Green,* Boston Consulting Group

Take urgent action to combat climate change and its impacts

CLIMATE RESILIENCE: THE $200 BILLION ENGINEERING CHALLENGE

Ian Allison
Global Head of Climate Resilience
Mott MacDonald

The UN Climate Change Conference (COP21) negotiations held in Paris in December 2015 culminated in a global commitment to drastically cut carbon emissions with the aim of limiting global temperature rises to 2°C above pre-industrial levels.

The significance of this in achieving the 13th Sustainable Development Goal (SDG 13), to take urgent action to combat climate change, cannot be overstated. The average global temperature rise is already approaching 1°C, triggering weather extremes that cause huge damage to infrastructure and put populations at risk. Even if we could cease carbon emissions today, further temperature rises are 'locked in' due to historic emissions and the delayed response in some of the Earth's natural systems.

Global economic losses to our infrastructure base attributed to climate impacts currently peak at more than $100 billion a year, with a clearly rising trend. We have also entered a period of unprecedented investment in infrastructure to meet the demands of a growing world population, urbanisation and the need for social development, especially in

the developing world. Extrapolating these two trends shows that climate-related losses will breach $1 trillion a year in the 2030s unless significant investment in climate adaptation is mobilised.

Protecting our assets from the effects of climate change will be one of the great demands made of engineers over the coming years.

Examining climate disasters reveals more about how insufficiently resilient infrastructure responds to severe climate impacts, and the effect on local populations.

In December 2015, as diplomats met in Paris to pledge the limit on global temperatures, people in the Indian city of Chennai struggled with the effects of extreme flooding after the most severe rainfall for 100 years caused widespread destruction and loss of life.

At the same time, Storm Desmond caused intense rainfall across the north west of England, resulting in Carlisle's flood defences – designed against a 250-year return period event – being overtopped, again causing major disruption and significant economic losses.

At the start of the year, a survey of 750 experts by the World Economic Forum singled out climate change as posing the biggest threat to the global economy - an analysis that provides a real challenge to the engineering community.

There is no comparison in the scale of the tragedy. Chennai is a dense urban area of some five million people and suffered more than 500 fatalities. Carlisle - with a population of 100,000 - saw one fatality attributed to the floods (the storm killed three people in the UK). But Carlisle also experienced greater proportional economic loss, with disruption, reconstruction and insurance claims already estimated to run in excess of £1.5 billion.

The difference in impacts in these two urban centres perfectly illustrates the difference in climate resilience in the developed world - where effects are felt mostly by infrastructure with large economic losses - and the developing world, where human losses are far greater.

These examples highlight the importance of climate resilience measures that are appropriate to local conditions. But climate resilience is more than simply funding a new sea defence or flood wall. Carlisle sits in a catchment with a particularly rapid hydrological response. The £32 million recently invested in Carlisle's flood defences are credited with delaying flooding and minimising the human tragedy, but did not prevent the flooding event from happening. 'Failing safe' must be a real consideration in all resilience planning. With climate impacts such as flooding set to become more frequent and extreme, there is an urgent need for broader measures to protect communities.

We estimate that within 20 to 30 years we need to be spending some $200 billion globally each year to provide adequate resilience. The good news is that the financial sector is beginning to respond to the threat of climate change. Investors increasingly look for sustainable and resilient investments. Insurers already take climate resilience into account, and poorly adapted assets will soon become uninsurable. New investment bodies, such as the UN's $100 billion a year Green Climate Fund, will raise the profile of climate resilient design.

The coming years will see accelerated government investment in climate resilience to protect communities and key assets. This will be complemented by an increase in developer-led and funder-led projects that make resilience a key requirement in order to secure financing.

Those entering engineering now need to consider climate resilience in a way their predecessors never had to, as design standards become less prescriptive and more outcome-based. Rather than specify the type, scale and dimensions of resilient measures, clients will demand that climate impacts are fully mitigated in a set area for a set time period. This changes how we think about engineering solutions, and how we deliver them.

At the start of the year, a survey of 750 experts by the World Economic Forum singled out climate change as posing the biggest threat to the global economy; an analysis that is unlikely to change for the foreseeable future and one that provides a real challenge to the engineering community.

Engineers entering the profession now will play a crucial role in ensuring new and existing assets are able to withstand this serious and growing threat.

14 LIFE BELOW WATER

Conserve and sustainably use the oceans, seas and marine resources for sustainable development

COMBINING ENGINEERING SOLUTIONS AND POLICY CHANGE TO CUT DOWN PLASTIC POLLUTION

Dr Sergio Diez-de-Medina Roldán

Researcher
Universidad Arturo Prat, Chile

Co-Founder
Chimera Innova Group

Globally, we produce 1.3 billion tonnes of waste per year. The daily contribution per person is approximately 1.2 kilograms, which is projected to double by the year 2025[1]. Approximately 11% of this waste is plastic, which frequently ends up in the oceans. Plastic pollution is disastrous for oceanic environments, affecting important species and ecology, and also the coastal economic activities in different parts of the world.

The first target of Sustainable Development Goal 14 (SDG 14) is 'by 2025, [to] prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities'. Within marine pollution, the plastic waste produced by land-based commerce is considered one of the biggest threats.

The complex hydrocarbons in plastics have an estimated biodegradation time of hundreds of years, which means that finding a solution to deal with the persistent pollution generated since the 20th century is urgent.

This solution can be achieved through sustainable engineering practices; translating the discoveries made by scientific research endeavours from pure knowledge into practical solutions.

On the northern coast of Chile, near the Atacama Desert (the driest non-polar desert in the world), the negative impact of plastic pollution is exacerbated by the extreme weather conditions typical of a harsh drought area. These include lack of rainfall, scarcity of clean, fresh water sources and presence of toxic pollutants in the minimal resources that exist. The toxic pollutants and plastics then drain into the coastal areas, with potentially disastrous consequences for oceanic environments.

Based on the needs displayed by local communities in the Tarapacá region of the Atacama Desert, the regional government in partnership with Universidad Arturo Prat is working to address the SDGs on a local scale with an experimental facility conducting research. In April 2016, a serendipitous discovery led to

One researcher, on using a plastic bag as a quick-fix for a roof leak, discovered several weeks later that it had began to degrade. On closer inspection, bacteria with the capability to degrade plastic and re-integrate it to the soil was identified in the bag.

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a promising new solution for the problems the region faces with plastic pollution.

One researcher, on using a plastic bag as a quick-fix for a roof leak, discovered several weeks later that it had began to degrade. On closer inspection, bacteria with the capability to degrade plastic and re-integrate it to the soil was identified in the bag.

This knowledge is now being turned into a practical solution to pollution, with a project to construct simple bioreactors and distribute them in the coastal regions most affected by plastic waste[2]. As well helping clean up oceans and the coast in Chile, we hope that the solution can be easily scaled and applied around the world. What's more, this engineering solution has the potential to be used on land too, in landfills already containing plastic waste, reducing the degradation time from centuries to weeks. This approach shows the importance of engineering in applying scientific research as practical solutions with immediate impact.

But, along with discovery and application of these new technological approaches to deal with the present and future issue of plastic waste in our oceans, other measures are also imperative. We need to make the population aware of the risks and detrimental effects that a simple habit can have on the survival of environments vital for the subsistence of our species. No matter how good our engineering solutions are, there will never be a substitute for reducing the problem at the source.

Genuine partnerships between stakeholders, including government entities, the private sector, academic institutions and citizens are needed to foster the sense of a proactive community working together to free the world from longlasting pollutants. Thankfully, many governments have already made a start towards achieving this objective by introducing economic charges on plastic bag usage by consumers, which, in the case of England, has reduced the consumption by 83%[3].

The case of Tarapacá in Chile demonstrates that engineering can help deal with plastic pollution, past and present. Nevertheless, these engineering solutions are most powerful in combination with better waste disposal policies, economic measures and alternative packaging options, which together can significantly improve the fate of our coastal and oceanic landscapes.

1 *What a Waste: A Global Review of Solid Waste Management,* The World Bank, April 2016
2 Project number FIC 2015 BIP 30434972-0
3 BBC News, http://www.bbc.co.uk/news/science-environment-36917174?utm_content=buffer46a33&utm_medium=social&utm_source=twitter.com&utm_campaign=buffer

Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation, and halt biodiversity loss

A HOLISTIC APPROACH TO REGENERATIVE DEVELOPMENT IS THE ONLY WAY TO HALT BIODIVERSITY LOSS

Dr Eduard Müller

President and Founder
University for International
Cooperation, Costa Rica

Humanity has taken dangerous steps in pursuit of its 'development', resulting in substantial losses in biodiversity[1] and ecosystem function[2]. Aware of the implications, in 2002 world leaders agreed that by 2010 a "significant reduction in the rate of biodiversity loss"[3] would be achieved. In the Global Biodiversity Outlook 3, in 2010, Ban Ki-moon, Secretary-General of the UN, stated: "… the target has not been met … the principal pressures leading to biodiversity loss are not just constant but are, in some cases, intensifying. The consequences of this collective failure, if it is not quickly corrected, will be severe for us all."

At the 2010 UN Climate Change Conference (COP10), once again nations agreed that it was of utmost importance to stop the loss and the *Strategic Plan for Biodiversity 2011–2020* was approved, including 20 targets to protect biodiversity, known as the Aichi Targets. With only four years left to meet the targets, a global assessment[4] indicates that Earth is now crossing the 'safe' limits for biodiversity loss in over half of the land surface, putting the ability

of ecosystems to support human societies at risk. One of the authors, Andy Purvis, states that "decision-makers worry a lot about economic recessions, but an ecological recession could have even worse consequences – and the biodiversity damage we've had means we're at risk of that happening. Until and unless we can bring biodiversity back up, we're playing ecological roulette."

Is sustainable development still achievable? I personally think not; damage to the planet is too great and we would need 1.6 planets[5] to sustain current consumption patterns. We need regenerative development: development that builds a viable, if different, future. Impact assessments must not aim at 'acceptable' levels. We require all endeavours to regenerate ecosystems and functional landscapes, to strengthen communities' resilience and capacity to adapt to a changing world, and allow for local culture and knowledge to flourish and not be lost to global markets. We must use creative management that looks into the future, incorporating climate change and socioeconomic scenarios, aligning actions to the achievement of the 'best' or 'less-worse' scenario.

We need regenerative development: development that builds a viable, if different, future. Impact assessments must not aim at 'acceptable' levels.

Belize World Heritage Site, and the need to leave space for nature to thrive without human (negative) intervention © Dr Eduard Müller

Why is it so hard to stop global change, climate change or biodiversity loss, to reduce poverty and famine and achieve peace? I think it is because we are not prepared to deal with complexity. To blame is the reductionist approach of western education, science and institutions whereby complex systems are divided into components, and studied through highly specialised disciplinary approaches, hoping that by understanding them we understand system function.

We missed the fact that interactions are more relevant, requiring holistic approaches that go beyond trans- or interdisciplinarity. Our universities and academics are heavily ranked by the number of publications in peer-reviewed journals, few of which are interested in holistic approaches, making it impossible for researchers to pursue a holistic career even if they wanted to. As a consequence, we are witnessing the extinction of our planet. We have

enough science, information and knowledge to understand what is happening but decisions are still being made without them. The current responsibility of a scientist is to publish; 'somebody else' is responsible for assuring that the knowledge reaches and is used by decision-makers.

Today, many tools are available for including biodiversity and ecosystem services through valuation (economic or other)[6]. Business and biodiversity platforms have been established and the Global Partnership for Business and Biodiversity[7] assists in this process. We must seek the true integration of biodiversity into business plans and national accounting (Aichi Target 2), beyond philanthropy.

Nevertheless, if we want to halt biodiversity loss, as the 15th Sustainable Development Goal (SDG 15) seeks to do, or even have success with any of the SDGs, we need to do things

differently. Knowledge has to become wisdom. Adapting to a changing world requires deep understanding of ecosystem function and this is tied to local knowledge.

If engineers want to be actors in regenerative development, they must look beyond the boundaries of their profession. Technocratic solutions will be crucial to assist in solving some of the issues but we need to go beyond technology and current science. Cosmetic fixes are not enough if we really want to achieve a new paradigm for development. Instead, we must incorporate solid values, ethics and transparency into all economic, political and societal action, using instruments such as the Earth Charter[8] and Pope Francis' encyclical letter Laudato Si'[9], if we are to better meet the complex and interactive problems our planet faces.

1 Secretariat of the Convention on Biological Diversity (2010) Global Biodiversity Outlook 3. Montréal, 94 pages.
2 http://www.millenniumassessment.org/en/Condition.html
3 https://www.cbd.int/2010/welcome/
4 https://www.ucl.ac.uk/news/news-articles/0716/140716-biodiversity-levels-unsafe
5 http://www.footprintnetwork.org/pt/index.php/GFN/page/footprint_data_and_results/
6 http://www.teebweb.org/
7 https://www.cbd.int/business/
8 http://earthcharter.org/
9 http://w2.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si.html

Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

ENGINEERING PEACEFUL AND INCLUSIVE SOCIETIES

Professor Calestous Juma
HonFREng FRS

Professor of Practice of International Development
Harvard Kennedy School, Massachusetts, USA

Author of *Innovation and Its Enemies*

Much of the conflict around the world is a result of social inequities that undermine societies' ability to pursue sustainable development. The focus on expanding human capabilities helps society to look to an open, positive and prosperous future. This is in contrast with a world in which the future appears closed with little opportunity for growth. Such a worldview is a major source of conflict, and individuals and communities resort to competing for seemingly limited resources instead of deploying their creativity to expand opportunities. Such inequities make it difficult for communities to leverage the world's scientific and technological knowledge and use it to advance development.

It is widely acknowledged that science and technology have an important role to play in meeting the UN Sustainable Development Goals (SDGs). To appreciate the importance of science and technology, we have to focus on the view that implementing the SDGs is a practical matter involving the application of useful knowledge encoded in engineering practices[1].

Such useful knowledge needs to meet two key criteria. It needs to be accessible and be based on inspirational lessons. The field of engineering offers the best possibility for combining these criteria into practical programmes that can show results within a generation.

Much of the engineering knowledge needed to enable countries, regions and communities to pursue sustainable development already exists. It is widely distributed in enterprises, in research institutes, and among private individuals worldwide. The best way to access this knowledge is by tapping into global knowledge networks.

The case of mobile technology in Africa illustrates this point. Mobile phones were not invented in Africa. But when they became available they provided a basis for the creation of new digital industries and businesses[2] that had not been anticipated by the original inventors.

The globalisation of telecommunications technologies makes it even easier for poor regions around the world to tap into the world's

There is ample evidence of countries that overcame poverty by harnessing existing engineering knowledge to promote development. Many of them laid industrial foundations using existing technologies from which they launched into new products and markets.

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fund of engineering knowledge for sustainable development. This covers emerging engineering fields such as synthetic biology, machine learning, drones, and 3D printing.

There is ample evidence of countries that overcame poverty by harnessing existing engineering knowledge to promote development. Many of them laid industrial foundations using existing technologies from which they launched into new products and markets. Technological leapfrogging is not just feasible, it is desirable for countries that seek to escape traditional growth patterns and promote green economies.

Unfortunately, countries and regions that are bedeviled by extreme inequities are also the ones with limited opportunities for obtaining engineering expertise. There are at least two ways to ramp up engineering competence in these countries.

The first is to make deliberate efforts to promote innovation[3] by adding engineering courses and modules to existing university curricula. This does not necessarily mean building new engineering schools, but it will entail bringing the logic of engineering to existing courses. This includes exploring how to add engineering components to the humanities and social sciences. Similarly, engineering courses need to have a stronger focus on solving social and environmental projects. Such efforts will help to reduce the traditional tensions between the arts and sciences.

A complementary route is to empower the private sector to play a larger role in offering engineering education. Many firms have high-quality in-house training programmes that could serve as new avenues for expanding engineering education for sustainable development. Achieving this goal requires formal recognition by governments that firms are important centres of learning and that some of their in-house training efforts could be supported and enabled to serve the larger public good.

The rise of nations such as South Korea, Singapore and China as global economic players illustrated the importance of expanding and deepening human competence. A key starting point in the growth process is recognising that building engineering capabilities offered the best opportunity for technological leapfrogging and catch-up in a variety of industries. The challenge today is to draw lessons from such inspirational examples and design development strategies with sustainability objectives in mind.

These proposals are only meaningful in environments where governments are committed to pursuing peace and prosperity through inclusive development. In his thoughtful advice to world leaders, Norwegian peace scholar Johan Galtung says the world will not achieve peace through security but will achieve security through peace. The first step in pursuing peace is to enhance human capabilities by expanding engineering education.

1   *Engineering Change: Towards a sustainable future in the developing world*, Peter Guthrie, Calestous Juma and Hayaatun Sillem, 2008
2   *Cashing In on the Digital Revolution*, Njuguna Ndung'u, Armando Morales, and Lydia Ndirangu, 2016
3   *Education, Research, and Innovation in Africa: Forging Strategic Linkages for Economic Transformation*, Calestous Juma, 2016

Strengthen the means of implementation and revitalise the global partnership for sustainable development

HARNESSING THE POWER OF TECHNOLOGY FOR A SUSTAINABLE FUTURE

Jan Eliasson
Deputy Secretary-General of the United Nations

The world is now poised to achieve transformative progress by carrying out the 2030 Agenda for Sustainable Development, our global blueprint for ensuring that all people live in dignity. Its 17 Sustainable Development Goals (SDGs) offer an unparalleled opportunity to build a new future. As with any endeavour, when it comes to construction, the engagement of engineers can drive meaningful global progress.

Now is the prime moment to optimise the power of these technologies to advance social and economic inclusion, promote environmental sustainability and help secure lasting peace. We live at a time of unprecedented technological innovation that is bringing together physics, biology, computer science and related fields with massive potential to change individual lives and national economies. Rapid advances in information and communications technologies, energy technology, biotechnology and other

cutting-edge innovations are dramatically altering manufacturing, construction and transportation. These trends should be shaped by wise investments and sound policies.

To make the most of the propitious intersection between the explosion in technological advancement and the articulation of the 2030 Agenda, we need to harness the contributions of the public and private sectors. Businesses are already investing significant resources in technologies that can drive progress across the SDGs. More and more companies are aware that what is good for the planet and people also benefits the bottom line. At the same time, governments will have to actively engage in creating markets for socially desirable products, including through environmental regulation, public procurement policies, subsidies as well as risk-sharing policies that encourage even greater progress.

The imperative of the 2030 Agenda to leave no-one behind should reframe the global focus

Rapid advances in information and communications technologies, energy technology, biotechnology and other cutting-edge innovations are dramatically altering manufacturing, construction and transportation.

Crossrail western tunnels © Crossrail

on how social needs can drive and transform science and technology investments. Efforts should focus not only on developing and deploying highly advanced and efficient 'hard' technologies, but also on supporting 'soft' or 'social' technologies that are tailored to change mindsets in different contexts and cultures.

There are many examples of the benefits of this approach. In developing countries, instituting a national 'vaccination day' or finding practical ways to bring the right medication to people who need it in time may be as important as research for new vaccines. In developed countries, we can reduce food waste through tax deductions from donating food and other incentives.

Engineers can add momentum to this movement for effective change by designing sustainable solutions on food, healthcare, water, energy, transportation, waste disposal, telecommunications and infrastructure. This is especially important for addressing the needs

of the most vulnerable people in the developing world. The low-carbon solutions that succeed in developing countries can teach the developed world how to advance sustainably, enabling all to 'leap-frog' over polluting industries and bring us closer to a green future.

The 2030 Agenda for Sustainable Development is universal. Where the Millennium Development Goals were a pact between donors and recipients, the SDGs break down that divide, generating instead a pact between governments and their people. To realise this vision of a safer and more sustainable future, we look to engineers as essential partners in moving from design to delivery.

ENGINEERING A SUSTAINABLE FINANCIAL SYSTEM

Rowan Douglas CBE
CEO Capital Science & Policy Practice
Willis Towers Watson

In the last quarter of a century, engineering-based methodologies, metrics and models have transformed the world's insurance market from a state of relative ruin to relative resilience. As the wider economy now confronts the risks ahead and aligns itself with delivery of the UN Sustainable Development Goals (SDGs), engineers and engineering-led expertise will play a central role in the design, regulation and operation of the wider financial system to reframe our development and reshape our environment.

In autumn 1992, the world's insurance and reinsurance market stood at the edge of an abyss. A six-year run of unprecedented losses from US liabilities, natural disasters and a North Sea oil platform, culminated as Hurricane Andrew slammed into the coast of Florida and Louisiana, unleashing $20 billion of insurance losses. These misfortunes were compounded by outdated underwriting practices, unmanaged risk accumulations and, in some cases, professional incompetence.

For the first time in 300 years, the international insurance market, and Lloyd's as it symbolic and economic epicentre, faced ruin and with it an essential economic and social foundation. Without insurance many things stop: airlines, mortgages, power plants, professional practice, healthcare, shipping and construction, to name just a few.

Amid the ashes of the insurance markets of the mid-1990s, three forces converged to drive a structural transformation in this market place: a new breed of 'smart capital' that demanded a new approach to underwriting risk, an analytical and scientific awakening, and a regulatory revolution.

In the late 1980s, three engineering consultancies emerged in the US that realised that this profession had the expertise to transform the underwriting of natural disasters. These firms were called catastrophe risk modelling companies or 'cat modellers' for short. Rather than relying on the recent past event in historical claims files as a guide, they contended that the probability distributions of seismic and extreme weather events could be described at underwriting locations and the vulnerabilities of exposed assets, structures and population

> Engineering metrics have become the bedrock of re/insurance pricing and risk management. They have transformed the industry from understanding risk through the history of luck to a far greater understanding of risk.
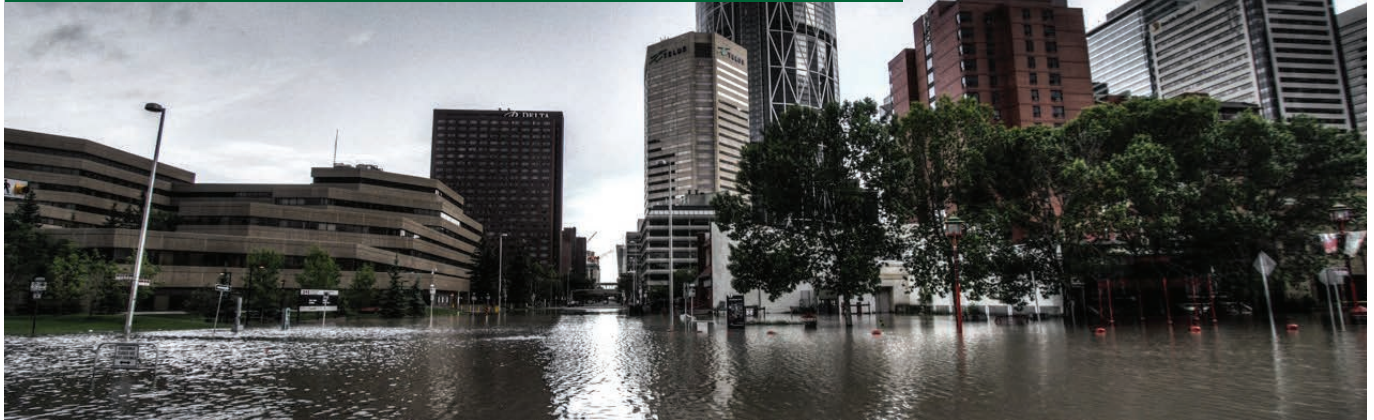
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to those forces could be evaluated. From the resulting combination of hazard probability, exposure attributes and vulnerability functions an estimate of annual risk could be derived. Such a formula is, of course, bread and butter to engineers designing structures or other systems, but it was novel to the insurance world requiring new data and underwriting tools. It sounded good to the new 'smart capital' entering the market to invest in re/insurance companies and they demanded these new 'cat models' were used.

But something even more profound happened. People concerned with the regulation of the insurance market and the protection of policyholders asked a fundamental question that had never been asked before. If an insurance contract is a promise to pay if something bad happens, what should be the tolerance level of and insurance contract, how much risk should it be able to handle? While at one extreme an insurance contract should not be expected to cope with the level loses that would come from the type of meteorite strike that doomed the dinosaurs, insurance is society's backstop. In 300 years this question has never been asked,

indeed the sector didn't have a lexicon or metric for answering it.

Once again the engineers came to the rescue. During the mid-1990s, a regulatory convention emerged in the UK and across much of the world that insurance contracts should be able to cope with the maximum probable annual losses expected once every 200 years. This was not just from natural disasters, but all risks; from financial markets shocks to mass tort liabilities. That meant that insurance companies should have financial resilience to that level.

Engineering metrics have become the bedrock of re/insurance pricing and risk management. The shape of a company's loss exceedance probability curve is now the reference point and negotiating crucible of reinsurance pricing and the determination of its regulatory capital requirements. It has transformed the industry from understanding risk through the history of luck to a far greater understanding of risk. A major landmark came in 2011, the world's worst insured natural disaster year on record with $121 billion in claims. Despite the unprecedented

losses the market was resilient because it was estimated as a one in 12.5 year, or an 8% annual chance of occurrence, far from exceptional compared to the annual losses that could occur.

Twenty-five years later, the global re/insurance sector is stronger and more resilient and sustainable than it has ever been despite a massive growth of risk over that time.

So, what has this got to do with *Engineering a Better World*? In 2016, the world's insurance industry has come together with the UN to help deliver the SDGs. At the heart of this is introduction of the type of engineering-based risk assessment and disclosure that will ensure that our wider investments and financial systems of the future are resilient, stress tested, and architects of a sustainable and risk sensitive future. Engineering expertise lies at the heart of this mission, which is:

'Understanding risk to create resilient platforms for sustainable growth and human dignity'.

IT'S TIME FOR THE WORLD TO WAKE UP TO THE POWER OF YOUNG PEOPLE

Rachel Litster
Global Accountability Manager
Restless Development

Change rarely begins at the top. Global problems often require the power of people, citizens, to take local action. I've witnessed countless young people use this power. Young people like Eva.

Eva, a 16-year-old girl from Tanzania, launched a campaign to provide clean water for her community. For three months, she has called on decision-makers to lead by example in turning the UN Sustainable Development Goals (SDGs), into reality. She ran a community event including decision-makers as well as community members and organised meetings with the local MP and district councillor before taking her message to the Prime Minister; now, her leaders are starting to listen. Recently, with the backing of 150,000 signatures for her petition, Eva met the Prime Minister of Tanzania to discuss getting a well.

This opportunity, the power of young people holding leaders to account, is one we cannot afford to ignore.

The world is currently home to the largest global youth population in history: 3.5 billion people on the planet are under the age of 30[1]. That's

over half of the global population. Half of the global population who will be disproportionately affected by poverty, inequality and climate change. The biggest mistake we can make is not to harness the collective power these young people can bring in reducing global poverty.

But we continue to live in a world where young people often lack access to, and inclusion in, decision-making processes on global issues. The UN Millennium Development Goals (the predecessor to the SDGs) were criticised for the limited accessible data they produced for citizens and governments to effectively understand and monitor progress towards them. Without citizen, especially youth, engagement in accessing and generating data to monitor progress, and the opportunity to effectively engage with decision-makers on this, we run the risk of governments failing to deliver on their promises.

Despite these challenges, most governments are formally committed to increasing accountability to citizens, and acknowledge that the participation of traditionally excluded groups, including young people, is central to achieving

The biggest mistake we can make is not to harness the collective power these young people can bring in reducing global poverty.

this. So how do we go about shifting power structures so that young people are included?

Providing young people with the data and networks to hold decision-makers to account enables them to play a vital role in ensuring the implementation of the SDGs. Young people bring unique skills to monitoring development: not only are they at the forefront of using social media and other innovative monitoring tools, they can also be effective 'infomediaries' (translators and sharers of information) and create new approaches to monitoring. When young people play an active role in holding decision-makers to account, there is an opportunity to connect power to youth and youth to power, recasting the relationship between decision-makers and young people.

Stories like Eva's are one of many. Take Natalie, a 23-year-old from rural Kenya. On discovering that information about the SDGs was not reaching her community, she decided to bring the conversation from the conference room directly to villages like hers. She says:

"We sought to simplify the information so that it could be better understood, especially by young people and communities. We are engaging young people on simple, day-to-day accountability practices, as well as analysing village development plans, how they link up to national development plans and align with Global Goal [SDG] targets."

Natalie is now supporting a network of young people to monitor progress towards SDG 5 (focused on achieving gender equality). Specifically, the network is reaching out to local communities to collect data on early and forced child marriage, an issue impacting young women and girls in Kenya.

In Ghana, despite government commitment and policy on reducing maternal mortality, implementation has remained weak. To address this, young people are accessing and generating data to monitor national progress towards SDGs 3 and 5 (both of which have indicators focused on reducing maternal mortality). They are working with local NGOs, and government to

identify data gaps, and using this as a tool to advise on progress.

These are just a few examples of how young people are using their 'youth power' to unlock data access, and in turn, ensure that decision-makers deliver on their promises. If we could channel this energy across the world's largest youth population, and into new fields such as engineering, imagine the collective impact this could achieve in ensuring governments remain committed to reducing global poverty. The UN's SDGs are the most ambitious set of development targets we've ever seen. That sort of ambition requires new ways of thinking that involves young people in their delivery, monitoring and accountability. It's time for the world to wake up to the power of young people and the data in their hands.

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1 *The State of World Population*, UNFPA, 2015

Sunset while preparing the deck hangers for installation on the Bridges to Prosperity suspension bridge in Tubungo, Rwanda © Flint & Neill

As the UK's national academy for engineering, we bring together the most successful and talented engineers for a shared purpose: to advance and promote excellence in engineering.

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Harnessing the expertise, energy and capacity of the profession to provide strategic direction for engineering and collaborate on soluti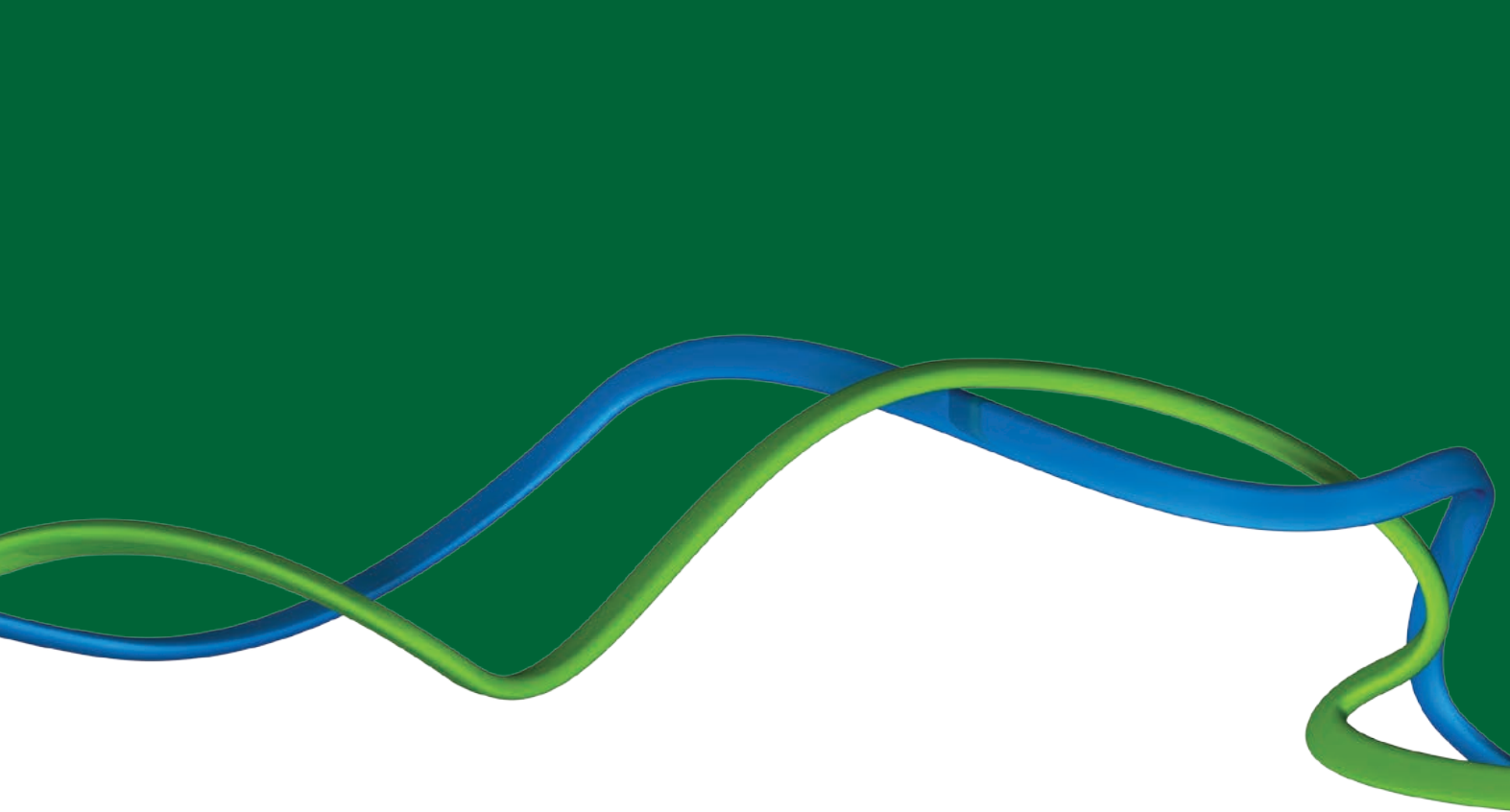ons to engineering grand challenges.