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Affordable, clean energy and climate action

SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all

SDG 13: Take urgent action to combat climate change and its impacts

Image by Warrenski, Flickr.

Thought leader

African development in a changing climate

The fossil-fuelled energy systems that fired the industrialisation of the western economies of Europe, North America, the USSR, and more recently the emerging economies have had a range of positive socioeconomic development outcomes. But these economic growth spurs came with environmental and (ultimately) social costs that are increasingly being felt, and will grow for many decades into the future. Climate change is one of the most high-profile examples of unsustainable development, write Mark New, Gina Ziervogel and Britta Rennkamp.

Adaptation to climate change

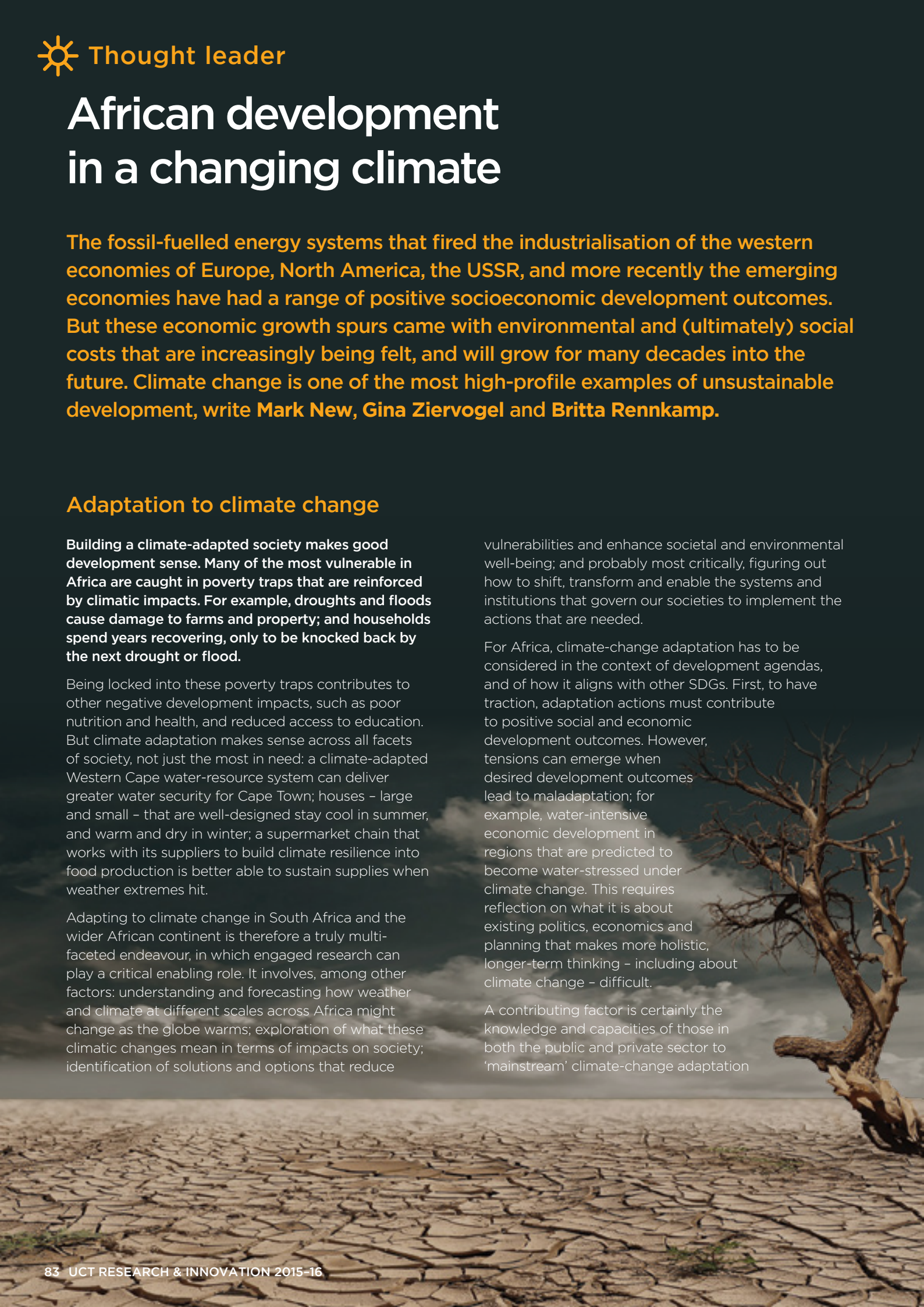
Building a climate-adapted society makes good development sense. Many of the most vulnerable in Africa are caught in poverty traps that are reinforced by climatic impacts. For example, droughts and floods cause damage to farms and property; and households spend years recovering, only to be knocked back by the next drought or flood.

Being locked into these poverty traps contributes to other negative development impacts, such as poor nutrition and health, and reduced access to education. But climate adaptation makes sense across all facets of society, not just the most in need: a climate-adapted Western Cape water-resource system can deliver greater water security for Cape Town; houses – large and small – that are well-designed stay cool in summer, and warm and dry in winter; a supermarket chain that works with its suppliers to build climate resilience into food production is better able to sustain supplies when weather extremes hit.

Adapting to climate change in South Africa and the wider African continent is therefore a truly multi-faceted endeavour, in which engaged research can play a critical enabling role. It involves, among other factors: understanding and forecasting how weather and climate at different scales across Africa might change as the globe warms; exploration of what these climatic changes mean in terms of impacts on society; identification of solutions and options that reduce vulnerabilities and enhance societal and environmental well-being; and probably most critically, figuring out how to shift, transform and enable the systems and institutions that govern our societies to implement the actions that are needed.

For Africa, climate-change adaptation has to be considered in the context of development agendas, and of how it aligns with other SDGs. First, to have traction, adaptation actions must contribute to positive social and economic development outcomes. However, tensions can emerge when desired development outcomes lead to maladaptation; for example, water-intensive economic development in regions that are predicted to become water-stressed under climate change. This requires reflection on what it is about existing politics, economics and planning that makes more holistic, longer-term thinking – including about climate change – difficult.

A contributing factor is certainly the knowledge and capacities of those in both the public and private sector to 'mainstream' climate-change adaptation



into their everyday practice and policy; universities such as UCT have a responsibility to develop curricula and professional courses that help build this capacity.

Second, and more critically, we have to question whether a climate-adapted society is achievable in the face of today's structural development issues. Can we expect government – on a national or local scale – to effectively support adaptation when many government entities are poorly governed and poorly resourced, both financially and in terms of human capacity? Can we expect those most vulnerable to climate change to prioritise climate adaptation when their day-to-day life faces much more urgent stressors, such as conflict, corruption and lack of basic infrastructure? Adapting to climate change – while challenging – also offers levers to address some of these structural development barriers, by ensuring that wherever possible, adaptation is transformative: by changing the structures within which adaptation occurs, and the agency of those individuals and organisations at the front line of the response.

By Professor Mark New, pro-vice-chancellor for climate change and director of the African Climate and Development Initiative (ACDI), and Associate Professor Gina Ziervogel, a lecturer in the Department of Environmental and Geographical Science, and research chair in the ACDI.

Mitigation of climate change and poverty reduction: trade-offs or win-win?

Combating human-induced climate change is not a challenge that exists in isolation. Developing countries, especially on the African continent, still struggle with income and energy poverty. Poverty reduction and provision of universal access to energy typically produce increases in greenhouse-gas emissions. Developmental pathways that reach prosperity without associated emissions increases are possible, but remain scarce in practice. Increases in the consumption, production and reserves of known fossil fuels on the African continent raise further concerns about their impact on our climate.

Despite these trends, climate-change issues in Africa continue to fall mainly into the category of adaptation. 'Adaptation' carves out a political space within the international negotiations under the United Nations Framework Convention on Climate Change (UNFCCC), which historically has made industrialised countries responsible for 'mitigation' to reduce emissions urgently. The convention establishes that climate-change responses must take "into full account the legitimate priority needs of developing countries for the achievement of sustained economic growth and the eradication of poverty".

The past decade showed changes in human and economic development that challenge the historical division of responsibilities in climate-change response. The majority of the world's poor no longer live in the least developed countries, but in middle-income countries. On the African continent, 23 countries have reached middle-income status, according to World Bank data.

Reaching middle-income status is obviously not a goal on its own. Economic growth, growing transport and energy use produce emissions that add to the problem of global climate change. A solution based on the assumption of global inequality in emissions may not hold in future. In middle-income countries, the urgency to address rising emissions, while reducing poverty and advancing economically, increasingly becomes a domestic-policy problem.

Research performed in a project on climate-change mitigation and poverty reduction has shown that the assumptions of trade-offs between measures for emissions and poverty reduction do not necessarily hold in domestic policy processes. The main barriers to implementation of measures for emissions reduction emerge from the distributional conflicts. The assumption of trade-offs between emissions and poverty reduction continues to dominate the discourse in international negotiations.

Comparative research on climate governance in three fossil-fuelled middle-income countries has shown that renewable energy programmes can successfully be implemented without international support for development or climate finance.

Distributional conflicts between the coalitions between beneficiaries and potential losers of climate policies are the main obstacles to extracting these win-win situations. Governments tend to prioritise socioeconomic development measures over climate policies. Researchers have focused on the questions of how to combine these measures and produce so-called 'co-benefits' for climate from conventional development policies, and vice versa. There has also been a special focus on the combating of energy poverty explicitly through the provision of access for productive use in informal enterprises, as well as on clean cooking technologies in low-income households in Southern Africa.

Future research will aim to expand the agenda on the question of how to achieve high prosperity in low-emissions development pathways further into the African continent.

By Dr Britta Rennkamp, a researcher in the Energy, Environment and Climate Change Group at the Energy Research Centre, and senior fellow at the ACDI. Feature image by Pixabay.

Feature

How climate change is causing pied crow numbers to soar

Pied crows, or *Corvus albus*, are a natural part of the landscape of southern Africa. They are bold, common and familiar. But there has been evidence over recent years, especially in South Africa, that there are many more of these birds than there used to be.

The increase is worrying some conservationists, who fear it could be having a negative impact on local biodiversity. These fears have some merit, given that the species is known to predate on birds' nests and young tortoises. Farmers are also concerned about the potential damage to sheep flocks, because crows pluck out the eyes of young lambs.

The effect of changes in temperature

Research confirms that there has been an increase in pied crows in South Africa, and quite dramatic changes in their centre of abundance. These changes vary throughout the country, with large increases in the south-west, but declines in the north and east of the country.

In addition, our results suggest that these changes are closely linked to climate change.

Using data from two bird atlases carried out 20 years apart, and linking these changes with information on the changing climate, we found that pied crows have increased mainly in the geographic areas of South Africa known as the Karoo and fynbos shrublands which are distinctive types of vegetation of south-western South Africa. This is where temperatures are increasing. These biomes are relatively arid habitats consisting principally of short shrubs, with very few natural trees.

The decline in numbers in the north-west of the country is most probably related to climate cooling in this region. It appears that the crows are following a warming climate bubble into the south-west. Our research suggests pied crows have a preferred temperature range roughly equal to an average annual temperature of 19°C. We are approaching this in the south-west of South Africa at the moment, and the crows are loving it.

Our results also suggest that this shift has been aided by the presence of power-line infrastructure. This has provided sites for crows to build their nests in what is otherwise a virtually treeless landscape.

We conclude that while power lines have facilitated the increase of pied crows in the Karoo, climate change has driven their soaring numbers in these areas. The combination of climate change and electrical infrastructure has created the 'perfect storm' of conditions to favour an explosion of pied crow numbers in the shrublands of South Africa.

An unloved species

Crows are big and obvious. Pied crows, in particular, are easy to identify, with their white tank-top plumage. These birds have had a bad rap globally. This dates back to medieval times, when they were reviled as carrion birds on battlefields; and large, black birds are superstitiously associated with ill omens or death.

Their collective noun – a murder of crows – doesn't exactly do much for their public image either. Given all this history, it is perhaps understandable that people react emotionally when they see crows doing what crows do best: being predators.

In South Africa, pied crows are notorious, and viewed with great suspicion by urbanites and rural farmers alike. They are accused of such gory deeds as plucking the eyes from newborn lambs, destroying the eggs of ground-nesting birds and decimating populations of tortoises.

They're also vilified for harassing other much more glamorous species, notably Verraux's eagles. Indeed, these perceptions have led to calls for the control of pied crows by those who are worried about their negative impacts.

But these observations are not sufficient evidence to suggest that crows have an overwhelming negative impact on ecosystems. A recent scientific review suggests that in general, they don t.

The truth is that their role within ecosystems is not necessarily that straightforward. For example, they also eat other predators, such as small snakes, which can be a major cause of nest failure in Karoo birds. Thus, increased numbers of pied crows certainly have the potential to change the balance of predator-prey interactions.

Given the situation, it may be that pied crows are an example of the relatively new phenomenon of the native invader. These are species that occur naturally in one area, but whose numbers suddenly increase out of all proportion with their surrounding ecosystems, shifting the balance of nature in unpredictable ways.

For a species to be considered a native invader in the truest sense, it needs to have a demonstrably negative

impact on other species. But while the pied crow clearly has such potential, we do not yet have the evidence to confirm they are causing declines of other species. Therefore, in assessing the pied crow 'problem', we must be careful not to jump to conclusions.

Climate change is ongoing

Throughout the world, animals and plants are responding to the changing climate by shifting their ranges, changing their behaviour, and changing their abundance.

But climate change is ongoing, so these shifts may continue to change over time. It is likely that we are not stepping into a new stable state, but rather witnessing one step in a continual transition, as species adjust (or fail to adjust) to conditions that are in a state of flux.

What happens next is uncertain.

As warming continues, will pied crow numbers in the south-west of South Africa subside again? Or will they adapt to their new conditions? Either way, it is still unclear what the legacy of the 'pied crow invasion' will be.

By Susan Cunningham and Arjun Amar, lecturer and senior lecturer at UCT's Percy FitzPatrick Institute of African Ornithology. First published in The Conversation. Images by Peter Ryan.

Thought leader

Fracking in the Karoo: pollution versus pay-off

Technological advancements over the past decade have led to a rapid rise in unconventional natural gas production, known as 'shale gas', particularly in the USA and Canada. The large-scale and rapid development of shale gas has resulted in an abundant and cheap energy source, with lower direct greenhouse gas (GHG) emissions than coal and petroleum. South Africa has the eighth-largest technically recoverable shale gas reserve in the world, located in three geological formations in the Karoo; surely, then, that should be cause for celebration? But global concerns about the environmental impacts of shale gas development and production on local water supplies, air quality and human health have made the process of extracting this natural gas – called hydraulic fracturing, or 'fracking' – a very contentious issue, writes Katye Altieri.

To frack or not to frack?

The economic value of this deposit has been estimated to range from 3.3 to 10.4% of Gross Domestic Product (GDP), while estimates of the number of new jobs that could be created in its extraction varies considerably, from 1 441 to 700 000. The potential impacts on GDP and job creation in South Africa – an upper-middle-income developing country with a 26.7% unemployment rate – are critical factors to consider when weighing up the pros and cons between shale gas development and environmental concerns.

A further consideration is the current power crisis in South Africa, in which the power parastatal Eskom has been unable to provide adequate electricity to match demand. Eskom is in the process of building two new coal-fired power stations, but this development is greatly at odds with South Africa's commitment to reduce GHG emissions in the coming years. Currently, natural gas contributes only 2.8% to primary energy in South Africa, and is used primarily to produce synthetic liquid fuels.

The development of shale gas in South Africa could lead to a significant shift in the electricity sector, by replacing coal-fired electricity. In addition, bridging from coal to natural gas could assist in South Africa's commitment to a peak, plateau and decline GHG emissions trajectory, as gas-fired electricity generation is compatible with energy from renewables in a way that coal and nuclear are not.

Air pollution and GHG trade-offs

However, the GHG-reduction benefits gained from shale gas are not guaranteed; neither does shale gas come without its own set of air pollution costs. Whether the

costs are worth it depends largely on methane leakage rates, strict monitoring and enforcement of best-practice regulations during fracking, and how the gas itself is used. Shale gas exploitation requires new wells to be drilled regularly and operate continuously, which results in 24-hour pollution from diesel generators, stationary engines and truck traffic transporting water and waste to and from the well pads. The main pollutants include nitrogen oxides (NO_x), volatile organic compounds (VOCs), and particulate matter (PM). NO_x and VOCs are precursors to ozone, which is linked to asthma, decreased lung function and premature mortality. Increased PM leads to increased hospital admissions, respiratory symptoms, chronic respiratory and cardiovascular diseases, decreased lung function and premature mortality. However, use of shale gas could result in considerable health benefits – despite the air pollution – if its use displaced other, dirtier, fuels such as coal or wood for use indoors in poorer households.

Filling the knowledge gap

The Karoo is a sparsely populated and vast area with low levels of industrial activity. Before shale gas exploration occurs in South Africa, it is important to investigate the potential negative impacts on air quality in the Karoo, as well as the potential benefits for GHG emissions for South Africa as a whole. Policymakers need to formulate an air-quality monitoring plan, and prescribe emissions regulation levels; but currently, they lack the basic information required to begin such an assessment.

A recent study conducted with my colleague, Adrian Stone, and published in the journal *Atmospheric Environment*, seeks to fill this gap in knowledge by developing a prospective air-pollutant emissions inventory for the NO_x, PM and VOCs associated with all aspects of shale gas. Emissions inventories can be used to establish regulations, devise enforcement strategies and health-risk assessments, as a predictive tool to establish monitoring strategies and as inputs to regional air-quality models.

The amount of air pollution that results from shale gas depends on the number of wells drilled, as well as the technology used. We constructed a well-development model for South Africa, using information from existing well fields in the USA and what is known about the scale of the Karoo shale gas field. A wide range of technologies were assumed to be possible, from old engines (e.g. those available from mining operations), which could lead to high pollutant emissions, to newer electric engines, which would minimise air pollutant emissions. All of the uncertainty was included in the emissions calculations, such that a range of emissions is determined – from the best case, of very controlled resource exploitation using clean technologies, to the worst case, of old polluting technologies and high levels of well development.

Prospective impact of shale gas on air quality

We find that the shale gas industry will probably become the largest regional source of NO_x and VOCs (bearing in mind the current under-development of the region), comparable to adding a city the size of Durban to the middle of the Karoo. Even if the lowest estimate of NO_x emissions is used, shale gas would be the fourth-largest source of NO_x nationally. Similarly, VOCs from shale gas activities would be the second-largest source of VOCs in the country. The high estimated values of NO_x and VOC emissions are a concern, for regional ozone and for compliance with national ambient air-quality standards. But emissions could be reduced, even with large-scale development, using already existing control technologies.

It is important to note that this is a prospective emissions inventory, for activities that have not commenced, and indeed may never happen. Good-practice guidelines will be needed to minimise impacts on air quality and reduce GHG emissions, with guidelines for control technologies, consideration of effective legal regulation, early establishment of baselines, and continuous monitoring and good governance enabled by co-ordination across several South African institutions – a challenging set of tasks. The literature on shale gas development is largely international, particularly from the USA, with relatively few studies undertaken in South Africa. This partly reflects different levels of development of shale gas, but points to the overall need for more research, including on air quality and GHG risks under South African conditions.

Renewable energy is available as nature provides it, not as a function of electricity demand. Therefore, demand and supply cannot always be matched. Natural gas electricity-generation plants respond to demand very rapidly compared to both coal and nuclear, which provide baseload electricity. Baseload plants can take several days to start up and shut down; and they run all of the time, providing a continuous level of energy. Natural gas peaking plants are smaller and can respond rapidly to changes in supply and demand. Thus, natural gas is quite compatible with renewable energy, as it fills the gaps in supply created by variable wind and sun.

By Dr Katye Altieri, research scientist at the Energy Research Centre. Image by South African Tourism, Flickr.

Feature

How one region is planning ahead to help farmers cope with climate change

In South Africa's Western Cape, agriculture plays an important role in the economy, job creation and socioeconomic development. But the sector is particularly vulnerable to a changing climate.

There have thus been calls for urgent action to guide and support the agricultural sector to adapt to the unavoidable impact of climate change, and to reduce its greenhouse gas emissions.

Relevant government departments recognised that a strategic and coordinated approach was needed to develop long-term resilience to climate change. This could be done through climate-smart agriculture and by placing the sector on a clear pathway towards a green economy.

To do this, the University of Cape Town and two provincial government departments – Agriculture, and Environmental Affairs and Development Planning – collaborated on the Smart Agriculture for Climate Resilience programme. It launched in August 2014.

First of its kind

This is the first provincial climate change policy for agriculture in South Africa. The project specifically focuses on food security and promotes climate-smart agriculture. It also aligns closely with the current five-year provincial strategic plan and the Department of Agriculture's strategic goals. One of the key goals is to optimise the sustainable use of water and land resources to increase climate-smart agricultural production.

The programme is premised on collaborative planning and action within and between the public and private sectors. This includes national, provincial and local government. It also includes organised agriculture and industry associations, farmers, agri-processors and agri-business, labour and civil society, and research and academic institutions. The project has thus far achieved an understanding of expected climate risks and impacts and vulnerabilities in agriculture. It has established the important linkages between resource sectors, water, energy and agricultural production. It also showed that vulnerability is high across the sector.

One of the project's key successes was a framework to battle the harsh impact of climate change. Areas that have a much milder climate and where climate change will not be as dramatic have also been identified. These may become the future centres of food production.

Capacity to adapt

There is existing capacity in the Western Cape's agricultural sector to adapt to the added stresses of climate change. Local companies are already providing energy-saving low-carbon solutions to farms and agri-businesses.

Leading wine estates have installed energy-saving measures and systems for renewable energy generation. The FruitLook project is using satellite images to help fruit farmers increase their irrigation efficiency. These solutions must be harnessed to stimulate innovation and technology transfer for climate-change adaptation and mitigation.

The resilience project hopes to ensure that the existing response capacity is developed to its greatest potential. It promotes responses that are practical, relevant and locally implementable over various timescales and budgets.

The project has taken a strong spatial approach, creating 23 spatial zones. This is because the risks and impacts of climate change will differ widely across the province. It is all dependent on climate, soils, vegetation and farming systems.

Western marginal grain zones such as the 'Rooi Karoo - Aurora' are expected to shift to livestock production. This zone will become hotter and drier. Some zones could benefit from mild warming and wetting, for example the southern 'GrootBrak-Plett' zone.

The project proposes a focus on four strategic areas with the aim to:

1 Promote a climate-resilient low-carbon production system that is productive, competitive, equitable and ecologically sustainable;

2 Strengthen effective climate disaster risk-reduction and management for agriculture;

3 Strengthen monitoring, data and knowledge management and sharing, and lead strategic research for climate change and agriculture; and

4 Ensure good cooperative governance and joint planning for effective climate change response implementation for agriculture.

It is also important that climate-change considerations be integrated into longer-term resource and economic planning. Another round of stakeholder engagements will ensure that the plan is realistic and implementable. The project will be completed during March 2016.

By Stephanie Midgley, a researcher and project manager in agriculture, food security and climate change at the African Climate and Development Initiative (ACDI). Main image by Dave Bezaire, Flickr. This article first appeared in The Conversation. Image above by World Bank, Flickr.

Feature

Fossil fuel interests might derail efforts to stem extreme global warming

The Paris Agreement, adopted by the United Nations in December 2015, aims to keep global warming to below 2°C; but unless countries ramp up their climate-change combating duties, global temperatures could rise by nearly double that by the end of this century.

This is despite agreement by countries to pursue efforts to stem global warming below even 1.5°C, says Professor Harald Winkler, director of the Energy Research Centre. Winkler co-authored a global study that urges governments, the private sector and civil society to increase their efforts to – essentially – save the world. The study was published on 30 June 2016 in the journal *Nature*.

Before Paris, each country submitted its strategy outlining how it planned to curb the increase in global temperatures and reduce climate change. However, these Intended Nationally Determined Contributions (INDCs) do not add up to the collective temperature goal.

"The centre of the article is an assessment of the effect of these current INDCs on reducing greenhouse gas emissions," says Winkler.

"But there are many other issues. The article is clear about whether the distribution is fair, and how much adaptation may be needed – adaptation is how we respond to impact. But the focus here is on mitigation."

In short, if countries continue with half-hearted implementation, we're on track to seeing global temperatures rise by as much as 3.1°C by 2100. This is a sobering scenario, admits Winkler.

"Essentially what we're saying is that what's been committed is great; the Paris Agreement also says more should be done," says Winkler. "If countries don't implement INDCs and stronger efforts in future, then we won't get to the stated goal."

The little that remains of a global carbon budget that would keep temperature increases well below 2°C might be used up as early as 2030.

Joeri Rogelj, a researcher at the International Institute for Applied Systems Analysis (IIASA), who led the study, says: "The Paris Agreement ... puts in place a flexible framework for a long-term transformation towards a low-carbon society. But our analysis shows that these measures need to be strengthened in order to have a good chance of keeping warming to well below 2°C, let alone 1.5°C."

Niklas Höhne, a researcher at both the New Climate Institute in Germany and Wageningen University, who also worked on the study, adds that reducing emissions by between 3 and 4 percent globally after 2030 would be needed to realise the Paris Agreement's goal.

"But in practice, switching to such stringent reductions right after 2030 would be challenging, and would require time – that means that in order to ensure a chance of meeting these targets, we need significant further action from countries before 2030," says Höhne.

What could happen if we don't make the 2°C threshold?

There's a whole body of work dedicated to the impact of climate change, and none of the predictions are comforting.

"The consequences range across everything from sea-level rise to waterborne diseases," says Winkler. "There are huge impacts on water systems for agriculture, with some areas getting wetter and others getting drier, but generally the predictions for climate change go along the lines of 'the higher the temperature, the more the risk of negative impact'."

Do all INDCs aim equally high?

The short answer is, no, they don't. But sometimes there are good reasons for this. Winkler's own research focuses on the question of equity, and the fair distribution of climate-change goals.

"Essentially, it's about political economy," says Winkler. "Fossil-fuel companies have a vested interest in high emissions. In our country, coal is the issue. We use coal for electricity. And 30% of our liquid fuel comes from coal. In other countries, the high-emissions interests are in the agriculture or forestry industries. Globally, it is the big fossil-fuel companies that need to imagine a very different future.

"So when countries have a national discussion, it's effectively a national negotiation, asking 'What can we do?' There's a little bit of an effect of saying, well, you know, if we take on a very large effort of reducing greenhouse gas emissions and our competitors don't, then maybe we're disadvantaging our economy.

"That may be a valid concern, but you can also make the argument the other way. To be competitive in the future low-carbon society, we should be investing proactively in energy efficiency, renewable energy and all low-carbon technologies right now. But even more fundamentally, we need to have a national conversation about how the structure of our energy economy needs to change. We need to position South Africa to be a leader in some part of the future low-carbon economy. That means taking a long-term perspective on near-term investment decisions. Or more plainly, investing in the future." Also, says Winkler, some countries may put less lofty goals on the international table; so that if they exceed these more moderate goals, they look good.

"I think it's fair to say that it's mainly the fossil-fuel industry that's holding back greater ambition," Winkler concludes.

About fossil fuels

Renewable energy has come on in leaps and bounds since Winkler arrived at UCT in 2000.

"From almost nothing, it's grown really fast. We're now seeing a lot of renewable energy. Some technologies, notably wind and photovoltaics (PV), are now cheaper than new coal plants. However, other renewable-energy technology, such as concentrating

solar power, is currently not cost-competitive.

"Wind and PV are now cheaper than new coal. That's an amazing turnaround. When I came to UCT in 2000, coal was considered the cheapest fuel for electricity – even in the world. That was partly because we weren't paying the carbon cost. Now we've passed a tipping point where the cleaner solutions are cheaper. And that's before the carbon tax has been implemented by treasury – that still needs to happen."

Unfortunately, says Winkler, people may only start acting against climate change once things are tangibly much worse.

Was the 2°C goal a compromise figure?

That number has been floating around for a decade or so, explains Winkler. There's been debate backwards and forwards between scientists and policymakers.

"The IPCC – the Intergovernmental Panel on Climate Change – has done a lot of work on the impacts of a given temperature increase, carefully assessing the probabilities and uncertainties over decades. What is very clear is firstly that climate change is 'unequivocally' due to human activity; and secondly that generally, the higher the temperature, the more negative impacts there are. For example, with 4°C, you'll get more sea-level rise than with 2°C.

"But then the scientists say, 'We can't decide. There's no such thing as a safe limit.' Science punts us back to the United Nations Framework Convention on Climate Change, which aimed (back in 1992) 'to prevent dangerous anthropogenic interference with the climate system'.

"What is 'dangerous' is a value judgment. What is risk? How many more people who get malaria are you willing to accept? Do you accept five? Do you accept 500 000? 500 million?

"So, responding to climate change is a prime example of the science-policy interface. You need both the best available scientific information and the value judgements made by political systems. 'Well below 2°C' is our best effort at putting a number to what is not too dangerous."

Accountability

Since the Paris Agreement, countries must report back on how they have been implementing their INDCs every two years, and they must develop new INDCs every five years, says Winkler.

"Up until Paris, it wasn't a requirement. Now it's mandatory."

Unfortunately, says Winkler, people may only start acting against climate change once things are tangibly much worse.

"If there was more extensive drought and more floods, if it becomes increasingly clear that the climate is changing, then I think people will say, 'Actually, this problem is real'."

By Yusuf Omar. Image by Tony Webster via Wikimedia Commons.