

SCIENCE FOR SOUTH AFRICA Quest

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IYBSSD2022

International
Year of Basic
Sciences for
Sustainable
Development

Do you know what this is?

Birding:
The most fun
citizen science

Strengthening
SA's wheat genetics

Dung beetle guts -
the critters inside
critters

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See the following video:

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International Year of Basic Sciences for Sustainable Development

The photo on our cover features a woman (we could unfortunately not find her name) from the Similaha Community Conservancy in Zambia using a treadle pump to irrigate her crops. A treadle pump is a human-powered suction pump that is used for irrigation. It is designed to lift water from a depth of up to seven metres. Treadle pumps were distributed to Conservation Agriculture farmers in Similaha through an initiative by Peace Parks Foundation (www.peaceparks.org), which is headquartered in South Africa. Farmers with access to donated treadle pumps and piping near a water source are able to irrigate their crops all year round, helping to provide food security during the dry summer months.

This is such a good example of how understanding and applying physics (a basic science) has helped provide solutions for sustainable development. There are, of course, many others.

This edition ties in with the International Year of Basic Sciences for Sustainable Development (IYBSSD 2022), which aims to raise awareness of the role of the four basic sciences – physics, chemistry, maths and biology – in developing sustainable solutions to the challenges of our time, and our planet.

Basic science quite literally permeates our entire universe. Appreciating this can start with the curiosity of children playing with bugs in the dirt or watching birds in the sky. Basic scientific principles can also – and should – have an impact on how we govern ourselves, how

we write laws and how we care for each other. That is why we included articles spanning a wide range of topics. From the power of birding to promote basic citizen science, the huge impact of sharing simple science stories, the microscopic critters that live in dung beetle guts, and even how it can snow in the Sahara! And because we believe basic sciences should also be applied to improve basic services, to develop human livelihoods in Africa in a sustainable way, we also look at the science and legislation of water services and public health, the various governmental structures ensuring municipal service delivery, and at some real metrics on whether South Africa is making progress with regards to its sustainable development goals.

The edition, my first as editor, therefore truly has something for everyone and we do hope you will enjoy reading it and be once more inspired about the role of basic science to help create a “better life for all”. That is, after all, our quest.



Fanie (RS) van Rooyen (Quest Editor) with support from Susan Veldsman, †Tsepo Majake, who sadly passed away on 20 June 2022, Prof. Himla Soodyall (ASSAf), Caradee Wright, and Joanne Riley (SAASTA).

Lesisiqephu sibopheke kwi International Year of Basic Sciences for Sustainable Development (IYBSSD 2022). Injongo yaso ukuqwashisa ngezinhlobo ezine ze sayensi-izibalo, ezobuchwepheshe, ikhemistri kanye nesayensi yezinto eziphilayo.

Translated by Zamantimande Kunene

FOSST Discovery Centre

The FOSST Discovery Centre initiative was established in 2004 and is aimed at enabling and encouraging high school learners to follow careers in Science, Technology, Engineering & Mathematics (STEM). Its main objective is to develop and produce more scientists and engineers from less-resourced schools in the Eastern Cape. These are the endeavors of the founder and director of the FOSST Discovery Centre, Mr. Phumezo Kwinana. The Centre is very instrumental in recruiting high school learners to study at the University of Fort Hare (UFH) through various activities. It is also aimed at conveying awareness of STEM to UFH and the general community.



Vision

To inspire and encourage youth to follow careers in Science, Engineering & Technology and sensitize the community on the benefits of science.

Mission

To provide an environment that enables the youth and community at large to pursue their interests in science.

Growth Development Programme

Provides a conducive environment for young graduates to thrive in different working fields viz. Science and Agriculture. The center plays a huge role in job creation as it equips graduates with necessary work-related experience.



Remote and Virtual Education Laboratory

ReVEL is an innovative online experimentation facility where students and researchers are able to perform experiments and interact with other students from over 20 universities globally. A first for South Africa, also discovered by Mr. Kwinana, hosted at the UFH. It is the only facility which converts traditional laboratories into Ultra-Concurrent Laboratories.



Mobile Laboratory Program

Science Experiments - The centre hosts learners for supplementary classes and experiments. This helps learners improve in Maths and Science.

Aeroponics - An innovative, sustainable technology to produce food using air and water without the use of soil. A first for UFH and FOSST under the leadership of postgraduate interns funded by NRF-SAASTA.

Youth Skills Development Programme

Robotics & Coding - Provides learners with basic knowledge on mechanical & electrical engineering and computer skills.





GETTING THE BASICS RIGHT

This year, 2022, has been declared the **International Year of Basic Sciences for Sustainable Development**, or IYBSSD 2022 in short. But what does that mean for us South Africans? And how do basic sciences – maths, physics, chemistry and biology – relate to our Sustainable Development Goals? Glad you asked.



INFO BITS

How does a cargo ship keep its balance in the water?

<https://www.batepapocomnetuno.com/post/the-ship-s-balance>

What are basic sciences?

<https://www.isp.uu.se/basic-sciences/>

Why are basic sciences important for sustainable development?

<https://www.iybssd2022.org/en/about-us/>

<https://pixabay.com/photos/container-ship-cargo-ship-freighter-596083/>

Every day, on a choppy sea off the Durban coast, huge cargo ships make their way with loads of thousands of truck-sized intermodal containers holding mysterious goods and materials. These could be vegetable products, or animal or vegetable fats and oils used in our everyday

households. How is it possible that these enormous vessels can stay afloat and manoeuvre across the ocean to their destinations, transporting much needed merchandise that ends up on shelves in shops, for us to purchase to make our lives more sustainable? At its core,



it is possible because of basic sciences, which include mathematics, physics, chemistry and biology. The vessel itself is prevented from tipping over because of mathematical calculations carefully designed and applied by engineers. And when it is empty? How does a vessel keep its balance in the ocean? The answer is easy: it adds weight in the form of seawater when it is empty and then releases the weight (seawater) while loading it with merchandise. Pumps are used to pull in and throw out the water when the ship is docked, exploiting simple physics.

But it does not stop here. If an empty vessel docks in the Durban port, it already contains seawater from a coast somewhere else. Let's say from China. The seawater from China is, however, not pure and contains a lot of microorganisms foreign to our Durban waters. According to International Maritime Organization regulations, ships must exchange water in the open sea, because there are different physical and biological conditions in any port, so some organisms cannot survive, or some foreign organisms might survive in port and so disrupt local ecosystems. However, water exchange in the open sea does not always happen. Aside from many ships not changing water at sea, there are several organisms that can resist both the travel and different environmental conditions. While being loaded with freight, seawater containing these non-native microorganisms is discharged to maintain the vessels' balance in the Durban water. This causes serious problems for the local fauna and flora, as well as public health. Can you also imagine the environmental impact? And this is where the importance of the study of biology comes in.

Linking basic sciences and the Sustainable Development Goals (SDGs)

From the above example, basic sciences impact our everyday lives in many unexpected ways that are often taken for granted. Furthermore, the successes and difficulties of the global fight against the COVID-19 pandemic over the last two years have been a stark reminder of the importance of basic sciences.

The 2030 Agenda is a universal call to action to end poverty, protect the planet and improve the lives and prospects of everyone, everywhere. Seventeen (17) goals were adopted by all United Nation (UN) Member States in 2015, as part of the 2030 Agenda for Sustainable Development, which set out a 15-year plan to achieve the goals. The 2030 Agenda resolution aims "... to end poverty and hunger everywhere; to combat inequalities within and among countries; to build peaceful, just and inclusive societies; to protect human rights and promote gender equality and the empowerment of women and girls; and to ensure the lasting protection of the planet and its natural resources. We resolve also to create conditions for sustainable, inclusive, and sustained economic growth, shared prosperity and decent work for all, taking into account different levels of national development and capacities".

On the 2 December 2021, the United Nations General Assembly declared that the world needs skills in basic sciences to achieve the 17 SDGs.

In line with this proposal, resolution 76/A/L.12 was approved by the UN Member States declaring the year 2022 as the International Year of Basic Sciences for Sustainable Development (IYBSSD 2022). The IYBSSD programme aims to highlight and prioritise the importance of basic sciences for sustainable development around the world.

The South African Department of Science and Innovation, National Research Foundation, Academy of Science of South Africa and IYBSSD 2022 Secretariat would like to invite schools, universities, science entities, libraries, museums, science centres and more to help promote the importance of basic sciences in our everyday lives.

Basic sciences meeting the challenges

The basic sciences are defined as the scientific disciplines of mathematics, physics, chemistry, and biology. They are called basic sciences because they provide a fundamental understanding of natural phenomena and the processes by which natural resources are transformed. Everything we do, and how we do it, has basic sciences at its core – from having clean running water, to switching on a light, to enjoying a healthy meal, to getting to school by bus, car or train. More examples include our mobile phones being used to communicate, listen to music, or access the Internet; or the vitamins and medication we might need to keep us healthy.

Unfortunately, not all have equal access to clean water, electricity, education, employment, food and more. We face challenges like the water crisis that was and continues to be experienced in KwaZulu-Natal, infectious diseases such as COVID-19 across the globe, and ocean deoxygenation and climate change, also across the globe. Gender equality continues to be an ongoing battle, especially in Africa. These are some of the challenges addressed as part of Agenda 2030 and basic sciences enable the necessary means and tools to address global socio-economic and environmental challenges.

Basic sciences provide the essential means to meet crucial challenges such as universal access to food, energy, health services and communication technologies. They enable us to understand the impact of the currently nearly 8 billion

people on the planet and to act to limit, and sometimes even to reduce, negative impacts such as depletion of the ozone layer, climate change, depletion of natural resources, extinction of living species etc.

Applications of general science and technology, like mobile phones and internet, are easy to recognise. On the other hand, contributions of basic, curiosity-based sciences are not well appreciated. They are, nonetheless, at the basis of major technological advances that stimulate innovation and are essential for training future professionals and for developing capacity of populations who can take part in decisions that affect our future.

The IYBSSD 2022 focuses on these links between basic sciences and the SDGs. According to Michel Spiro, President of the International Union of Pure and Applied Physics, this is a unique opportunity to convince all stakeholders that through a basic understanding of nature, actions taken will be more effective, for the common good.

The benefits of IYBSSD 2022 are especially important for African countries where young people have limited insights into the scientific environment which could inspire careers that offer unique and unparalleled opportunities for them to use their intellectual strengths and abilities to address the global challenges outlined in the SDGs. By increasing an awareness of basic sciences, curious young minds might come up with new inventions and discoveries, which can improve the wellbeing of our people and our planet.

Science is interwoven into all of our lives and is also the roadmap to improving the quality of life of people and the care of our planet. Highlighting the basic sciences during IYBSSD 2022 is vital to ensuring this close relationship is strengthened to aid in the improvement of life around the globe for all – irrespective of socioeconomic status, race, ethnicity, gender, sexual orientation, disabilities, and more.

Article written by Prof. Himla Soodyall , Executive Officer of the Academy of Science of South Africa (ASSAf), Ina Smith , Planning manager at ASSAf, and Raj Mahabeer, Programme Officer: STEAM and Humanities, at ASSAf.

Welcome to the STEMulator world

Explore > Discover > Learn

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Hidden World Revealed



<https://pixabay.com/photos/adventure-backpack-bag-boy-scout-1807495/>

The science of stories, and the stories of science

***"Let me tell you a story ..."** We tend to sit up and listen when we hear these words. We all love a good story. When it comes to science, the art of telling a good, compelling story is becoming ever more important. And that's a good thing – because stories make science more engaging.*

Scientists who study the way humans communicate tell us that our brains are wired for stories. When we hear a story, our brain cells light up with activity. That is why we enjoy stories, why we remember them and also why we often re-tell them.

Understanding the power of stories, and how our brains respond to stories, explains why storytelling is such a good way to share science.

When we hear a compelling story, and especially if we can identify with the characters, it feels as if we are

experiencing it ourselves (this is also called 'narrative transportation').

Stories are not only more engaging than facts, but also more convincing. People are much less likely to argue with the key message of a story, compared to when they are given information in a different format. A well-told story may leave us curious to find out more and willing to act on its lessons.

Good (science) stories can help to make science part of our everyday lives and help people to make sense of new advances and issues in science.

What is a story?

We often think of stories as fairy tales and myths. But stories can also be factual and true to life. A story takes place at a specific time and in a specific place; and it describes the actions of one or more characters that lead to a series of events that are linked to each other.

A key ingredient for success is that stories contain a human element in the form of drama, conflict and emotions. When the characters in a story experience setbacks and struggles, but also successes and victories, we 'feel' those highs and lows with them. That is why we care about what happens. Therefore, in a story about science, there can be facts and information, but they should be 'covered up' (or disguised) by emotions. A good story makes people think, but also makes them feel.

The structure of a good story

In terms of its structure, a story typically has a clear beginning, middle and end.

The beginning sets the scene. Then, something changes. For example, the lead character faces a specific challenge.

Then, there is a journey of ups and downs, and turning points. The events are linked (this is called 'causality').

Tensions rise, until it reaches a dramatic high point and the challenge is conquered. Following that, the tension decreases and the issue is resolved. It is this classic structure, also called a 'narrative arc' that takes us along on a journey and holds our attention.

The whole series of events changes the reader, because you end up in a different place compared to where you started. For example, you may see things differently or understand something that you did not grasp before. Very often, that is the purpose of a good story – to effect some kind of change in people's behaviour or attitudes about a specific issue. A good story can change the way people see the world.

From science to story

In the context of a science story, the 'beginning' can be about why this topic (or this research) is important. The middle will focus on the research that was done and the

findings, but there will also be some conflict, uncertainty, controversy or concerns. This is how you build tension, keep interest and make the reader care. The ending will be about the outcome of the research, how people can benefit from it and what it means to society.

If you think about scientific research as a way to solve problems, find solutions and explore the unknown, it is clear why we can tell good stories about science. When scientists set out to discover something, for example a new vaccine, the story can take us on a journey of successes and failures, with tension building as we move closer to the discovery. The discovery can be unexpected and surprising, but will increase our overall understanding in ways we could not have imagined at the outset.

In another scenario, scientists may step in to help people after a specific loss or setback. As these stories unfold, the scientists can emerge as saviours, rescuers and heroes that inspire hope through the solutions they find.


When scientists try to solve things we don't understand, the storyline can take the form of a mystery tale. In this case, the scientists become detectives that follow leads even though they are not sure what they will find. Along the way, they look for answers and explain the implications, thereby engaging listeners to care about the final outcome.

Advice for writing or telling science stories

There are many ways that scientists, and science students, can tell stories about their work. One of the best ways is to tell a story of something you were involved in yourself, for example a specific experiment or project. What did you find out? What happened that you did not expect? What challenges did you face to find your answer? What new perspective did you gain? Tell the world your science story. Putting a human face on science helps people to connect and care about the story. People won't easily cry about numbers or graphs, but a story about people can bring the science to life and make them care.

People connect more easily when scientists show their own passion and curiosity, and share their own hopes and fears in the stories they tell. This builds trust with their readers and listeners, and can invoke a sense of awe and wonder. When scientists are honest about their own failures and mishaps, people can relate to that. It helps them to understand that scientists are not perfect and that science is a human (and thus a relatable) endeavour.

Good visuals can help to draw readers in and are an essential component of a compelling and immersive story. Similar to the text, visuals that contain action and emotion are the most effective.

Article written by Dr Marina Joubert , science communication researcher at Stellenbosch University.

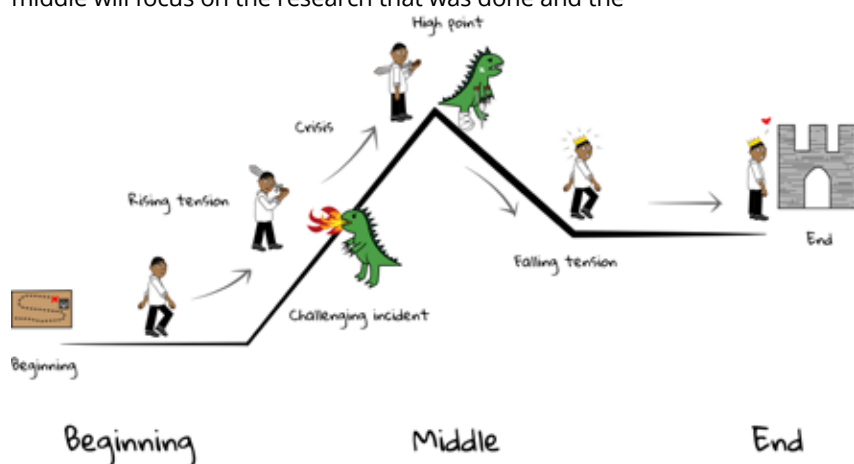


Illustration by Fern Waddilove

BIRD IS THE WORD

The power of birding, birders and citizen science



<https://pixabay.com/photos/bird-fynbos-protea-sugarbird-3862991/>

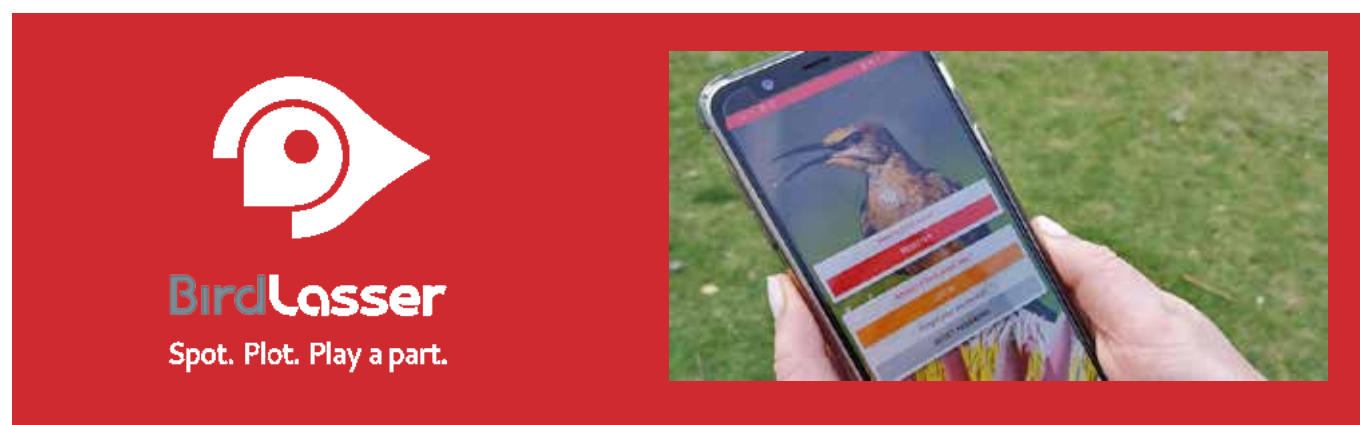
Birding is fun. If you haven't tried it, you should. It is social, competitive, colourful, and takes you to places you might never have seen. Also, it boosts local economies through the buying of equipment, outdoor gear and access permits, and plays a big role in tourism. But most importantly (for me, the scientist) birding generates crucial data that helps determine the conservation status of birds and informs the management plans to save endangered species.

So, what is birding? In its simplest form, it is just looking at and enjoying birds. It is a pastime associated with well-being and connecting to nature. It provides intellectual stimulation: identifying a bird requires careful attention to detail, so that one can tell it apart from similar species. It is entertaining: the multiple soap operas and dramas that occur as birds go about their daily lives are the subject of documentaries. In every garden there is an on-going saga of feathered Love and War.

Birds can tell you a lot about where you are. If you were kidnapped and transported away from home, and locked in a dark room, by listening to birds you would be able to tell if you were in an urban or rural environment and what part of the country you were in. If you hear South African endemic Cape sugarbirds, you're in the Fynbos of the Western Cape. If you can hear house sparrows or common starlings, you're in an urban environment; and if you can hear kelp gulls, you're by the sea. Someone took you to Cape Town! A braying African penguin? You're not far from Boulders Beach! Send a message to the police and await your rescue.

Birds can tell us about the state of our environment. Visiting our arid regions, we can tell if there is a drought and how bad it is by looking at the birds. In good years, the Karoo is full of nomadic bird species: lark-like buntings and yellow canaries. These disappear in a drought, leaving only hardy resident species. Raptors and large-bodied birds disappear when human impacts become too great. Vultures, one of the most endangered large-bodied bird groups, are replaced by pied crows.

Want to start birding and simultaneously become a budding (birding) citizen scientist? BirdLife South Africa recommends the Birdlasser app (available on Apple's iStore and Google's Play Store for Android):



Listing heroes

So if birding can entertain you, educate you, and possibly save your life, is there anything you can do in return to help those in need? The next step up in the birding ladder is to create a list of species you have seen. There are many apps to assist, and I strongly recommend BirdLasser. It is free to download through Google Play Store. With BirdLasser, you can choose to submit your lists directly to species causes with BirdLife South Africa. What is just a name in your list has data associated with where you were and when you saw the bird. From this simple activity, scientists can calculate where species are and create dynamic range-maps. They can calculate if a species is spreading or changing migration patterns. By simply recording what you saw, you are on the path to becoming a citizen scientist, one of the most useful forms of humans on the planet. Citizen science projects range from identifying stars, to taking photos, to making simple lists of birds.

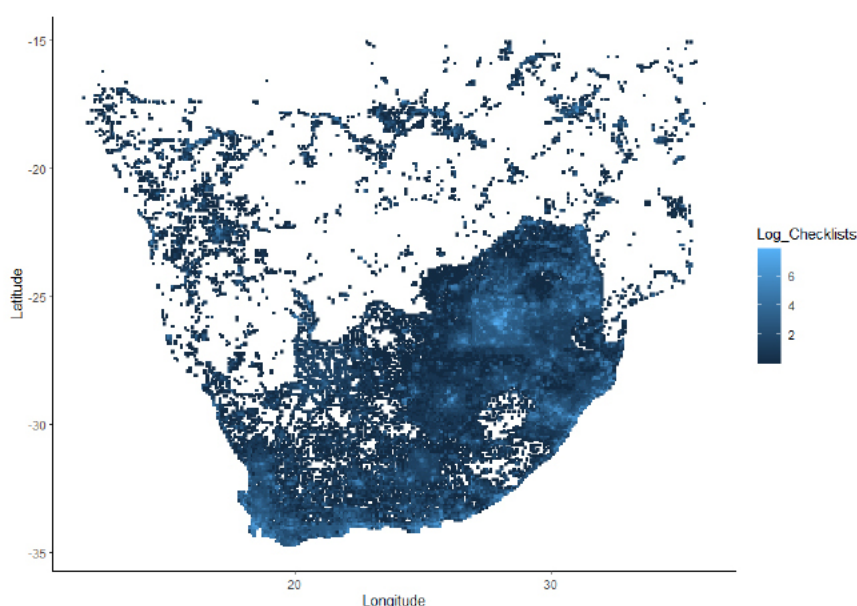
Atlassing agents

Could it possibly get any better? Yes! Through BirdLasser you can also send your lists to the Southern African

Bird Atlas Project (SABAP2). You'll need to register first at sabap2.birdmap.org. Here, thousands of bird lists for geographic sampling units (called pentads) are housed at the University of Cape Town. This information is used to calculate not only where species are, but how common they are. With this, we can tell if a species is becoming more common, or more rare. Lots of information is free for the public to use, including distribution records for a particular species, and species lists for selected sites. SABAP2 data is extensively used by environmental consultants to inform developments. Birders who contribute to SABAP2 are called 'atlassers' their systematic birding is called 'atlassing', and they are the elite of the birding world – from the conservation and science point of view. They are highly useful members of society.

SABAP2 is a truly amazing citizen science project. The data is used by scientists across the world. SABAP2 builds on SABAP1, which was undertaken from 1987 to 1992, resulting in one of the most impressive bird books ever produced: *The Atlas of Southern African Birds*, published in 2 volumes. The distribution data has been used in a wide variety of papers, from illustrating patterns of taxonomic relationships to the impacts of climate change. Bird field guides use the maps to illustrate bird distributions.

SABAP2 has birthed a range of similar projects across Africa. The most successful until now are the Kenya Bird Map project and the Nigerian Bird Atlas Project. There are fledgling projects in several other countries. These projects all use the same protocol (BirdMap) and are collectively referred to as the African Bird Atlas Project. The BirdMap protocol requires that at least two hours of active birding is undertaken in a pentad. A pentad is an area of 5x5 minutes. The two hours can be spread up to over 5 days. Only after 5 days can a new list be started for the same site. It might



The area covered by the Southern African Bird Atlas Project (SABAP2).

sound complicated, but BirdLasser automatically records where you are, how much time you've spent actively birding, and when a new list needs to be started. All you have to do is type in the names of the birds you have seen, and then occasionally submit your data to the project.

A review of how the SABAP2 project is used was published in the *South African Journal of Science* (<https://sajs.co.za/article/view/12030>). The authors found over 700 articles that either use or refer to the atlas projects, spanning a range of media from websites, books, environmental impact assessments (EIAs) and over 150 peer-reviewed scientific articles. It should be noted, the EIAs were only those publicly available on the web (many are not). There has been a steady increase in the use of SABAP2 data since its inception in 2007. With this data now providing information to Namibia, Botswana, Zimbabwe, Mozambique, Eswatini and Lesotho, there is no envisaged end date.


Some interesting examples of the data use include illustrating that the increase in pied crows in the Western Cape is due to a combination of climate change shifts coupled with infrastructure development. Pied crows, while indigenous, are a concern because they prey on vulnerable small tortoise species. Another example highlights how unique Africa is in terms of its urban bird



Agulhas Long-billed Lark_00001

composition: our urban bird communities have more scavenging species (like pied crow, but also yellow-billed kites, marabou storks and African sacred ibis), but urbanisation is also linked to the loss of habitat specialists and larger bird species (storks and most eagles).

So, we encourage you to pick up your binoculars, go outside, watch some birds, record what you see, and embark on a journey that will enrich your life while also contributing to science and society. It is probably the easiest, most fun science you can do. If you need more helpful resources, get in touch or visit birdlife.org.za.

Article written by Alan Lee , Science and Innovation Programme Manager for BirdLife South Africa. Alan is the organisation's main Data Scientist, responsible for providing scientific input into ecological monitoring and research on priority threatened species and habitats.



<https://pixabay.com/photos/hornbill-bird-safari-perched-5982474/>

Isenzo esilula esifana nokubuka izinyoni singaba usizo kwi phrojekthi yezesayensi, uma ababuki bezinyoni babelana ngolwazi labo lokubona izinyoni kanye noso Sayensi. Lokhu kwabelana kungenzeka kalula kusetshenziswa ubuchwepheshe be App obubizwa ngokuthi i BirdLasser. Lokhu kungasiza oso Siyansi ukuba bakwazi ukubona ukwehla kwenyuka kwezinyoni ezweni lonke.

Translated by Zamantimande Kunene

Dung beetle guts!

A look at the critters that live inside other critters



Figure 1: A dung beetle rummaging through buffalo dung for something to eat.

Insects owe a lot of their success to unseen microorganisms that they have evolved symbiotic relationships with. A fascinating example is that of the dung beetle's gut symbionts.

Insects are the most diverse group of animals on the planet, with almost 1 million described species. They are widely considered to be one of the most successful groups, exploiting almost every resource. Their widespread success could be partially assigned to their close association with symbiotic microorganisms.

Symbiotic microorganisms are organisms that work together for mutual gain. In this case it may include bacteria, fungi, archaea and protists that work together with insects. Great assemblages of symbiotic microbes are found inside insect guts; this is what we call the gut microbiome or microbiota.

The gut microbiome of insects has allowed them to do amazing things. For example, the gut microbes of wood-feeding termites aid them in the digestion of plant cell walls. This allows termites to exploit and utilise a previously inaccessible resource. Some evidence suggests that insect gut microbes detoxify plant chemicals to overcome the plant's defences. This is especially prevalent in agricultural pest species, such as the coffee berry borer that detoxifies caffeine through its gut microbes. Symbiotic gut microbes are not only involved in nutrition. New research suggests that the gut microbiota of honey bees can regulate their immune system. The presence of a healthy core gut microbiota has also been shown to provide disease resistance to honey bees.

Dung beetles and their gut microbes

Although quite small and easy to miss, dung beetles have a disproportionate effect on their environment. They are referred to as *ecosystem engineers* as they provide many ecosystem services that positively affect their surroundings. Dung beetles most often feed and breed on mammal dung that they bury underground. This ultimately moves nutrients below the surface, preventing parasites or flies from breeding and provides fertiliser for plants to grow. Dung beetles are therefore important in agricultural areas, especially livestock farms, where they increase pasture health by removing and circulating animal waste. They are the real clean-up crew of the Earth!

Although dung beetles perform astounding feats, recent research suggests that they receive aid from microorganisms in their guts. These interactions are often overlooked due to their perceived insignificance and difficulty to investigate. The study of dung beetle gut symbionts has not received much attention. However, the few studies we do have show promising results and further our understanding of the complex interactions concerning symbiosis within living insects.

Dung beetles possess very specific gut microbiomes that differ greatly between species. Surprisingly, small changes in the gut microbial community of an insect could be fatal. How they came to acquire these symbionts is still up for debate, but diet plays a large role in dung beetle gut microbiome composition. This is due to the large majority of gut symbionts helping dung beetles (and other insects) digest food. This corresponds to what we know, since scientists have found an abundance of plant-degrading bacteria within some dung beetle guts.

Other notable gut symbionts break down amino acids, digest biomolecules and cellulose, or ferment carbohydrates. This, in turn, provides the dung beetle

with essential nutrients. The symbiosis is so important, in fact, that some dung beetles have evolved fermentation chambers in their gut, where they house an abundance of symbiotic bacteria that help them digest food. It is clear that without these gut microbes, dung beetles would not be as successful as they are today.

Conservation threats to dung beetles and their gut microbes

Although very important, the symbiotic relationship between dung beetles and their gut microbiome is under increasing pressure. Gut microbes are usually very specific, and a disruption in this community can be catastrophic. When scientists swapped the gut microbes of two closely related dung beetle species, they observed catastrophic die-off. There are three main threats to this important symbiotic relationship.

1. Antibiotics

Most of the antibiotics sold around the world are used in livestock farming to promote growth and prevent infections. Up to 90% of antibiotics are excreted through the animal's urine or faeces. This poses a problem for dung beetles as their diet now consists of many antimicrobial compounds. Dung produced by animals treated with antibiotics changes the gut microbiome of dung beetles. The observed effects persisted even 23 days after the beetles were exposed to treated dung. Ultimately, this will likely disrupt the symbiotic relationship between dung beetles and their gut microbes, affecting their immunity and nutrient uptake. Antimicrobial compounds also have potential sublethal effects that could hinder their ability to recycle nutrients and contribute to pasture health. This highlights the fact that although antibiotics may not be directly toxic to some animals, they could have unforeseen side effects such as changing a non-target organism's symbiotic gut community. Antibiotics further increase greenhouse gas emissions as methane (CH₄)-producing bacteria are found to dominate antibiotic-treated dung.

2. Pesticides

Pesticides are used by farmers for various purposes: some are used to protect crops from pest insects and others to protect livestock from parasites. Farmers commonly use Ivermectin to kill lice, ticks and other parasites associated with their livestock. Unfortunately, these pesticides also negatively affect both the animals and those feeding on their dung. Ivermectin has been found to disrupt the gut microbiome of cows and up to 98% of the Ivermectin administered to cattle is excreted in their dung. Dung beetles then take up this pesticide while feeding or breeding in the cow dung. Scientists found that Ivermectin gets stored in the gut and fat bodies of dung beetles up to 12 days after exposure. As diet plays an important role in insect gut microbes, Ivermectin could ultimately disrupt the dung



Figure 2: One hypothesis is that dung beetles originally gained their gut symbionts through the food they ingested. Not all gut symbionts are present when the dung beetles emerge. Some are gained through the environment. Illustrated by Kara du Plessis.

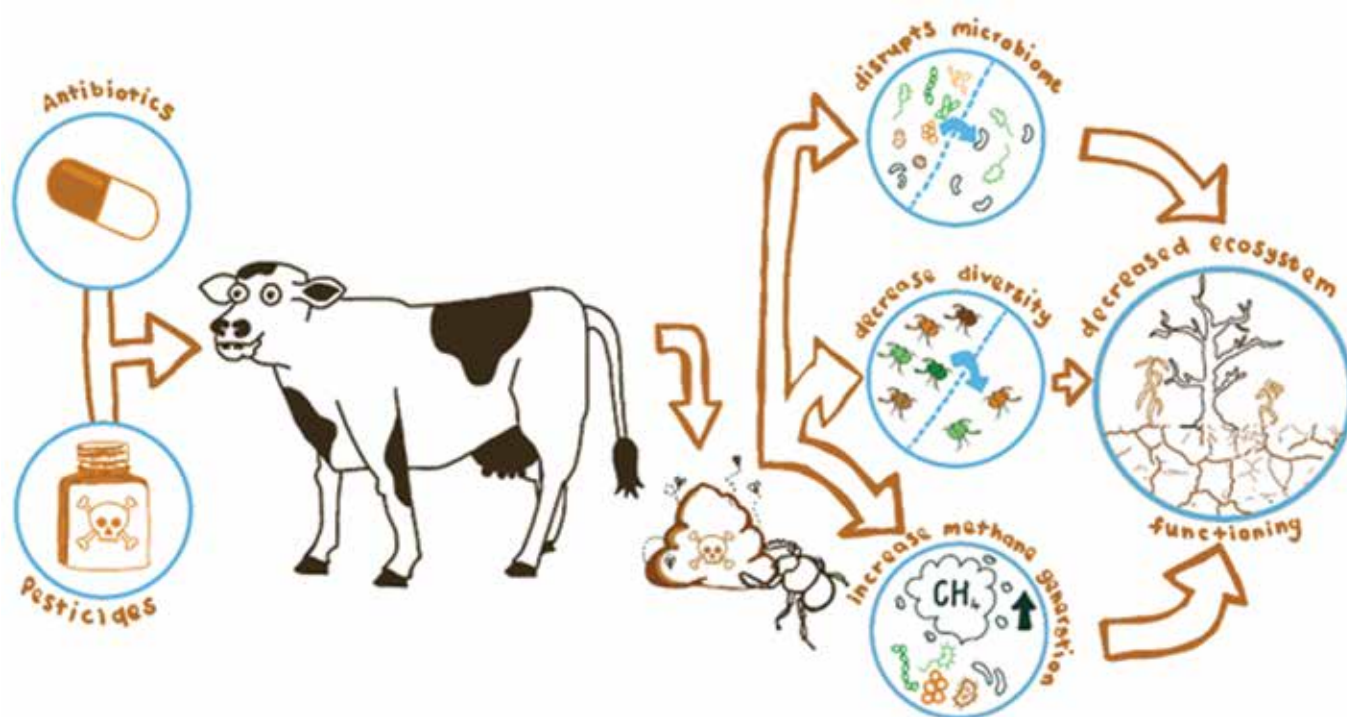


Figure 3: The dung by mammals treated with antibiotics or pesticides has disastrous consequences for all animals that depend on dung. Antibiotics and pesticides are ingested by the dung beetle subsequently affects their gut microbiota. Many sublethal effects have also been reported and can lead to disastrous consequences for the ecosystem. Illustrated by Kara du Plessis.

beetle's gut microbial community structure. This will cause important microbes to die off or be replaced. Ivermectin residue is further linked to lower dung beetle diversity and a reduction in the ecosystem services they provide. Other pesticides, such as pyrethroids that are used in crop protection, are also known to disrupt insect gut microbiomes. Chronic exposure to these pesticides will ultimately lead to a disrupted gut microbiome in most insect groups. This causes an array of negative effects for insects and there is no reason to believe that dung beetles won't be affected in the same way.




3. Climate change

The effect climate change has on dung beetle gut microbes has not yet been studied in detail. Climate change research requires us to have years of prior data to track changes over time, however, dung beetle gut microbe research is a recent phenomenon. For that reason, we use the data we have now to predict what might happen when temperatures increase on the Earth. If temperatures increase by 2°C, studies show that the insect gut microbiome will get disrupted. This trend is observed in multiple animals and shows how

temperature-sensitive the gut microbiota of insects are, because insects are ectothermic and therefore rely on external heat. We will know the full extent of this effect once we have long term datasets.

Conclusion

Dung beetles rely on symbiotic gut microbes to help solve a range of problems. This is especially true in their digestion of food. The evidence is convincing that the disruption of this symbiosis will cause many negative consequences. For a sustainable future where dung beetles remove our waste and recycle nutrients, we need to farm and live responsibly. This includes reducing our reliance on antibiotics, and only using them when absolutely necessary. We should stop regular and unsustainable pesticide use and reduce our carbon footprint by improving our understanding and adhering to long term strategies.

Article written by Johann de Beer , part of the Invertebrate Biosystematics and Conservations Group (IBCG) at the University of Pretoria (UP), Kara du Plessis , an MSc candidate at the UP working on stress in impala, who kindly drew all the illustrations in this article, Prof. Catherine Sole , head of the IBCG, and Prof. Christian Pirk of the UP's Social Insects Research Group. All authors are affiliated with the University of Pretoria's Department of Zoology and Entomology.

Ubuwazi ukuthi eziswini zezinambuzane ezifana ne zinkubabulongwe, kunezicutshana ezincane eziphilayo ezinomsoco? Lokhu kungasiza ukuba siqonde ukuthi lezicutshana ezingaphakathi kwethu, zisisiza kanjani ukuba siqinise amasotsha omzimba futhi simelane nanoma yini ehlazela umzimba wethu.

Translated by Zamantimande Kunene



Water services, South African law and your health

South Africa faces an ever-increasing water resource and service delivery challenge, especially in its cities. Here too, science, and the right legislation, can make a difference.

According to the most recent Statistics South Africa (SSA) General Household Survey, almost one-third or 29% of households reported dysfunctional water supply services in 2020. Access to water also declined in six provinces between the years 2002 and 2020, with the largest declines observed in Mpumalanga, Limpopo and the Free State. This is worrying, given that the COVID-19 pandemic highlighted the absolute importance of access to clean water for hygiene and sanitation purposes.

Water cities

The promise of access to safe, reliable, and nearby water supplies has always drawn people to urban areas. This is likely because access to water in metropolitan areas is reportedly higher, with 98,1% of households having access to piped or tap water in their dwellings. Furthermore, water interruptions are less frequent in metropolitan

areas compared to households nationally – 12,1%, compared to 28,6% (number of households who reported interruptions over a 12 month period).

However, during pandemics, residing in densely populated urban areas poses many public health risks and challenges. Science tells us that urban areas or cities are ideal spaces for the spread of infectious diseases such as COVID-19. This is because issues that are often found in cities, such as inadequate and polluted water, waste and sanitation access, and management challenges, increase the risk of infectious diseases. Buildings that lack effective ventilation systems could lead to respiratory tract diseases, while crowded and densely populated areas in cities increase shared airspace and intensify peoples' risk of exposure to infectious diseases.

It is for this reason that effective service provision, particularly water services, becomes essential to sustain communities' public health and safety. This leads us to the question: what does the law say regarding the provision of water and public health services in South African cities?

Your water rights, according to law

Our first point of entry is that cities, also known as local governments or municipalities, are generally responsible for providing services that benefit the local community. These services include municipal health, municipal public transport, and water and sanitation services. As such, the Constitution of the Republic of South Africa, 1996, (the highest law of the land) tasks cities to provide services to local communities in a sustainable manner, thereby bearing in mind the needs of future generations.

These services are so essential that cities are required to structure and manage their administration, budgeting, and planning processes to give priority to the basic needs of the community. In a court case concerning the City of Johannesburg, the court explained that the provision of basic municipal services is a cardinal function, if not the most important function, of every municipal government.

Next, it is important to note that, in South Africa, everyone has a constitutional right to have access to sufficient water. This does not mean that everyone has an immediate right to water services, but that over time the government must take reasonable steps within its available resources to realise this right.

The Constitution also clarifies that cities are required to provide water and sanitation services limited to potable water supply systems and domestic wastewater, as well as sewage disposal systems. Therefore, cities play an important role in achieving the realisation of the constitutional water right.

Furthermore, the constitutional water right is put into action through legislation, specifically the Water Services Act 108 of 1997. The Act provides for the rights of access to basic water supply and services and sanitation in the country. The Water Services Act also says that while cities, who form a part of the local sphere of government, are responsible for water services, the national and provincial spheres must offer their support.

The Act recognises that the right of access to basic water supply and sanitation services is needed to ensure sufficient water, and an environment that is not harmful to our health or wellbeing. Science plays a very important role in this regard, because science tells us whether or not water is safe to drink, informs us of how much water we need to survive, and so on. The law enforces this and requires cities to adhere to these standards to protect communities' health. Under the Water Services Act there are rules, or 'regulations', as well as norms and standards in place that

provide guidelines on what is meant by basic water supply, potable water and basic sanitation.

For example, it holds that the minimum standard for basic water supply services is education on proper water use and a minimum amount of drinkable water of 25 litres per person per day (or six kilolitres per household per month). This water should be available at a minimum flow rate of no less than ten litres per minute and must be within 200 metres of a household. Moreover, basic water supply services should be effective so that no one is without a supply for more than seven full days in any year.

Environmental health services

In addition to water services, we are fortunate enough that the Constitution requires district and metropolitan municipalities to provide certain services to ensure we live in a safe and healthy environment, and maintain our public health. These services are called municipal health services, and arise from our constitutional right to an *environment* that is not harmful to our health or wellbeing.

Therefore, these services are concerned with environmental health. Environmental health is a branch of public health involving all parts of the natural and built environment that may affect human health. Another law, called the National Health Act of 2003, tells us exactly which municipal health services cities must provide. These services include, for example, food control, waste management, the surveillance and prevention of communicable diseases (such as COVID-19), and environmental pollution control.

Water testing

Notably, municipal health services also include water quality monitoring. Thus, before water is provided to households, the water provider (often the city) must test the water for harmful substances. The water must adhere to specific scientific standards as prescribed by the South African National Bureau of Standards. These standards include that the water must not contain health risks (for example, *Escherichia coli* or faecal bacteria, or illness-causing parasites) in excess of certain limits that may cause acute or chronic health problems. It is also tested for aesthetic and operational risks with limits on, for example, the fluoride, ammonia and sulphate levels in the water.

Biology tells us that a variety of pathogens (organisms causing disease to its host), bacteria and protozoa (single-celled organisms that may cause diseases) are transmitted by water. These organisms, called microorganisms, often cause illnesses such as cholera, dysentery, and gastroenteritis, all of which are associated with polluted water. To determine whether water is safe from these harmful organisms, scientists have to rely on 'indicator organisms', or organisms whose presence show that water is potentially unsafe or polluted. Since most of the common water-borne diseases are caused by pathogens in the faecal-oral route, South Africa's domestic water quality

guidelines provide that drinking water must be tested for faecal pollution. This would be indicated through the presence of, for example, *Escherichia coli*.

Therefore, the South African law recognises that there is a vital link between water services and public health, particularly the spread of diseases. The COVID-19 pandemic again illustrated how important it is for cities to be aware of this link when providing services to communities, but it also highlighted many existing vulnerabilities in our country that continue to exist.

Pandemic measures

To protect public health during outbreaks of infectious diseases, such as COVID-19, in cities, improved access to safe water, sanitation, hygienic and good environmental conditions are essential. However, access to water, sanitation and hygiene services is very limited in low-income countries and densely populated cities. This leads to the challenge of preventing potential future outbreaks by curbing transmission of diseases like COVID-19.





For example, hand hygiene, a major protective measure recommended by the World Health Organisation to prevent COVID-19 transmission, is not adequately provided for due to underfunding in many low-income countries, including South Africa.

COVID-19 showed that there is an urgent need to address historical gaps in water supply in South Africa. As a short-

term response to the pandemic, South Africa's disaster law and response measures allowed us to set up water supply points across the country for hand washing. Similar measures have been adopted in Ghana and Peru.

Research shows that in the medium to long term, however, the law will have to prioritise developing and expanding current water and sanitation systems to underserved areas, such as in large and ever-developing cities. But the law alone is not sufficient to protect us; national and provincial governments will continue to play an important role in supporting local governments to provide sufficient and safe water. Science will also play an important part in early-warning systems for disease outbreaks in large and densely populated areas. Maintaining proper scientific testing of water will similarly prevent the spread of dangerous diseases, and protect us from consuming unsafe water.

We must also work *together* with city governments to protect ourselves and ensure we have access to vital water services. We can do this by, for example, reporting water leaks to the city immediately, and avoid wasting or polluting precious water sources.

Article written by Nicolene Steyn , Chantelle Moyo , Nonhlanhla Ngcobo , and Meeschka Diedericks  of the South African Research Chair: Cities, Law and Environmental Sustainability at the Faculty of Law, North-West University (NWU). The research was conducted with the financial support of the National Research Foundation of South Africa (NRF) (Grant No 115581). Views and errors are the authors' own and do not represent the views of the NRF.



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Uthini umthetho mayelana namalungelo okuthola amanzi okuphuza aphephile nahlanzekile? Ilovo umbuzo esiwuphendulayo kulesisihloko-kanye nokuthi I Sayensi isisiza kanjani ukuba sihlale ukuthi amanzi ngempela aphephile empilweni yakho.

Translated by Zamantimande Kunene

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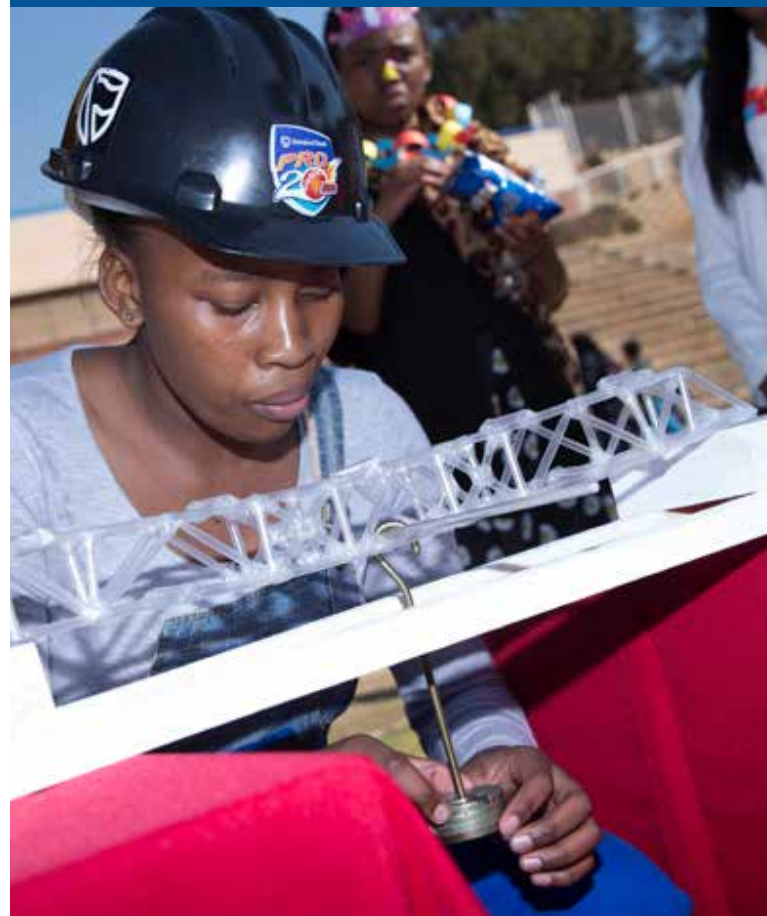
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South African local, provincial and national government:

A shared responsibility for adequate service delivery

The responsibility of ensuring adequate municipal services to South Africans is shared by local, provincial and national government – and scientific research plays an important role to inform joint government efforts.

All cities, towns, farms and other pieces of land in South Africa fall under the governance of municipalities (also called local governments). Municipalities are responsible for the delivery of basic municipal services to their communities. These services include the supply of electricity, waste collection, road maintenance, and the purification and provision of drinking water. These services sustain human life and make it possible for people to live healthy lives.

The simple science of services

Medical and environmental management sciences tell us that the failure to provide these services endangers human health and threatens the natural environment. Research conducted by economists tells us that basic municipal services are also necessary to support local economies. Businesses depend on reliable electricity and water for their operations. These services also ensure that people can live and work in dignified, safe and healthy environments.

If people do not have access to adequate water to drink and sustain hygienic lifestyles, they will turn to unhealthy sources of water such as dams, rivers and ponds that are not intended for daily domestic use. Municipal roads that are not maintained pose safety risks (such as potholes) to pedestrians and vehicles.

Local, provincial and national spheres

Communities work closely with their municipalities. Hence, when they are not happy with the delivery of basic services, they will blame their municipalities. Although this is not wrong, we must remember that the South African government is made of three spheres, which are national, provincial and local. Municipalities are the local sphere of government.

The national government, which is made up of the President, Cabinet and national departments (such as the Department of Basic Education), is responsible for issues such as education, health, and issuing of birth certificates and identity documents, among others.

Basic services, on the other hand, can be delivered best by municipalities. However, all the three spheres of government must assist and support each other in the delivery of these services. For a municipality to effectively collect waste, it may need financial support to buy refuse collection trucks, fuel and safety clothing, and to hire people such as drivers and waste pickers. The national government provides money for these services.

A better life for all – together

When South Africa transitioned to a democracy in the early 1990s, the government committed to providing a better life for everyone. This commitment was supported by several laws and policies that give the government a duty to provide basic services. Hence, local communities have a right to demand these services from their municipalities. The *Constitution of the Republic of South Africa, 1996*, is the highest law in the country. It says that everyone has a right to food, water and a clean environment that is not harmful to health.

The local government must ensure the protection of these rights using its financial resources and administrative capacity. Municipalities may also make laws (called by-laws) on matters that are given to them by the Constitution, such as basic services. Municipalities may also make by-laws on matters usually administered by provincial and national government when these are assigned to them.

Furthermore, municipalities also have the right to exercise powers that belong to provincial and national governments when such power is reasonably necessary for the effective performance of their functions. However, municipalities are not left to their own devices as the Constitution allows for the support and strengthening of municipal capacity by the national and provincial governments. Additionally, provincial and national governments might intervene when municipalities are unable to provide service delivery.

Municipalities are also entitled to a share of national revenue to enable the provision of basic services and the performance of the functions. They may also require their communities to pay fees for services such as water and electricity.

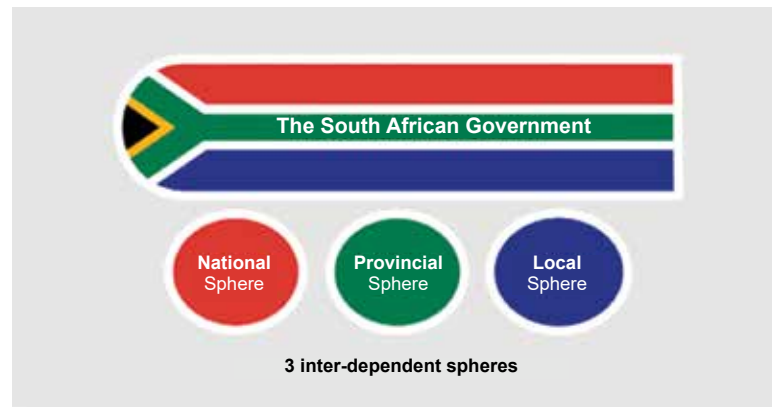
It is not always easy to comply with the law. The promises in law are difficult for municipalities to fulfil for several reasons. However, in a recent case decided by the High Court in the Eastern Cape Province, it was shown why it is important for the three spheres of government to provide people with basic municipal services.

The Makana case

The case involved the Unemployed Peoples' Movement and the Premier of the Eastern Cape Province. It also included many other parties, such as the President, the Minister of Cooperative Governance and Traditional Affairs and the Minister of Finance. This case was launched because of the worsening service delivery in the Makana Municipality in the Eastern Cape. Hence, the Makana Municipality, its Executive Council, the MEC for Cooperative Governance and Traditional Affairs, and the Executive Mayor of the Makana Municipality were included in the case.

The Makana Municipality faced many financial problems, which made it impossible for it to provide basic services such as water and sanitation. The people constantly faced sewage spillages, and there was a large pile-up of waste because the municipality was sporadically collecting refuse, leading to pollution. The municipality failed to repair the roads, leading to enormous potholes. The people also suffered because the municipality could not provide electricity reliably, as it was not paying Eskom. At the time, Eskom was threatening to cut off electricity supply for failure to pay.

In the light of these factors, the court was asked to declare that the Makana Municipality had not complied with the Constitution and other laws regarding its obligations to provide basic services. It was also asked to decide whether the provincial government, led by the Premier, was obliged to intervene in the Makana Municipality. The court decided that the Makana Municipality was in serious financial trouble, and that it was unable to provide basic services like water, refuse collection, electricity and repair of the roads. Since the municipality was unable to fulfil its duties, the court said that it was time for the provincial government,



led by the Premier of the Eastern Cape Province, to intervene in the municipality to help it return to a position where it could provide basic services. The court said that regardless of political and other reasons, the provincial government could not sit on the fence while the people in the municipality suffered from the lack of delivery of basic services.

The Makana case shows us that municipalities may not always be able to provide basic services such as water and sanitation. They may also fail to provide electricity and to repair roads. As a result of such failures, the residents may face hardships such as lack of clean water, pollution through refuse and sewage spillage, and unreliable electricity supply. When this happens, the people, businesses, and the environment suffer. Hence, it is important for the provincial and national governments to keep an eye on municipalities that face problems and help them, where necessary, before it is too late. In certain cases, such as the Makana Municipality, it is necessary for the provincial government to intervene timeously. Where the provincial government fails, it may be up to the people in the municipality to approach the courts to order the provincial authorities to step in. While this is a possible remedy, the important message is that the *entire* government as well as local communities should find ways to work *together* to help ensure the safety and health of people living in South Africa's towns and cities.

Science for services

Equally important is research by natural and social scientists that helps decision-makers in government better understand the needs of people, the health, economic and other impacts of failing municipal services, and the potential of information and other technologies for service-delivery improvement. Scientific research should also help us see and appreciate the critical linkages between the natural resource base necessary for services such as water provision, the decisions that people in power (government) make and the living experience of people inhabiting the towns and cities of South Africa.

Article by Felix Dube , Anél du Plessis  and Maricéle Botes  of the Faculty of Law at North-West University of the NRF SARCHI Chair in Cities, Law and Environmental Sustainability (CLES), Faculty of Law at North-West University.



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Pushing the boundaries of SA wheat genetics

Genome sequencing is a rapidly growing research area that has come a long way since 1990 when scientists first began to sequence the human genome. At the same time, huge strides have been made to sequence the genomes of crops to increase disease resistance, yield and drought tolerance, for example. In South Africa, efforts to unlock the secrets of wheat genetics are showing promise for better wheat harvests, and increased food security.

The human genome, which is the entire genetic sequence (DNA) that makes you human, consists of 6.4 billion base-pairs of DNA. Now, imagine an organism that has three times the genome size of a human being! That's wheat.

It's quite humbling to realise that bread wheat (*Triticum aestivum*) has a much more complex genome than you do. The wheat genome is roughly 16 billion base-pairs long – in total that's almost 100,000 genes.

cengen



An international triumph for resistance gene cloning and hexaploid sequencing

South African company CenGen (Pty) Ltd, and their collaborators from King Abdullah University of Science and Technology and The University of the Free State, have had their hands full sequencing and deciphering this massive wheat genome. This team sequenced and assembled the whole genome of Kariega, a South African wheat cultivar. The genome was further used to understand the exceptional disease resistance displayed by this South African wheat cultivar. Recently, their research efforts were published in *Nature Genetics*, currently making the Kariega genome sequence one of the most accurate wheat genome sequences in the world. Additionally, this team also showcased how their genome sequence can be used to accurately identify a wheat disease-resistance gene, *Yr27*.

Why is it important to study the genome sequence of a crop?

The term 'sequence' is used to describe the DNA code that makes up any living organism. DNA is made up of nucleotides which can be represented by nucleotide bases (A's, T's, C's, and G's). What makes you unique is the order or 'sequence' in which those A's, G's, T's and C's appear in your

genome. In order to be able to 'read' this sequence as you would read a book (Figure 1), scientists need to shear the genome into small fragments, read the smaller fragments, and then try to piece the genome back together again to make a 'complete' gene sequence. The entire collection of DNA, in the correct order, that makes up an organism, is referred to as its genome.



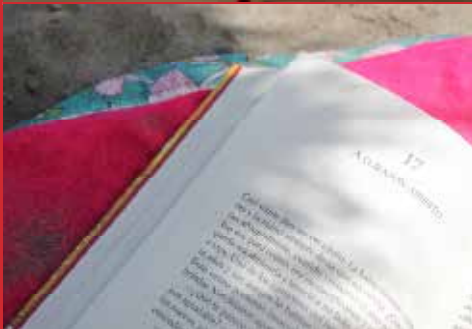

1		An entire genome can be thought of as an encyclopedia collection. If we had to print the genome of wheat, it would fill roughly 16000 books!
2		There are many volumes within an encyclopedia collection. Similarly, there are many chromosomes that make up a genome. A chromosome can be thought of as a single volume. The wheat genome has 42 chromosomes.
3		Within a single volume of a book, there are many chapters. Chapters can be thought of as sections of a chromosome. When finding disease-resistance genes, we look for sections of the chromosome that might be correlated to a specific trait of interest.
4		Within a chapter, there are many words. Words can be thought of as individual genes. Cloning of a gene helps us find the exact position of a word in a set of encyclopedias, or discover the definition of that word (what the function of that gene is).

Figure 1: A comparison made between the wheat genome and an encyclopedia set

Sequencing of a plant genome (especially of a consumption crop like wheat) will provide the necessary encyclopedia of genes that will form the backbone for gene discovery. At the very least, the genome sequence will represent a valuable shortcut, helping scientists find genes much more easily and quickly. The process that scientists go through to track down a single gene responsible for disease resistance is shown in Figure 2, using the example of the *Yr27* stripe rust disease-resistance gene. This process is referred to as gene cloning.

The process involved in cloning the *Yr27* disease-resistance gene

The approach taken in this study combined plant pathology, genetics and bioinformatics. The diagram in Figure 2 aims to show the use of these scientific areas and how they facilitated the cloning of *Yr27*. Any attempt at a gene cloning project begins with an interesting observation in phenotype (how the plant looks). In the case of this study, the focus was on disease resistance, so the phenotype of interest was visible resistance against stripe rust exhibiting healthy

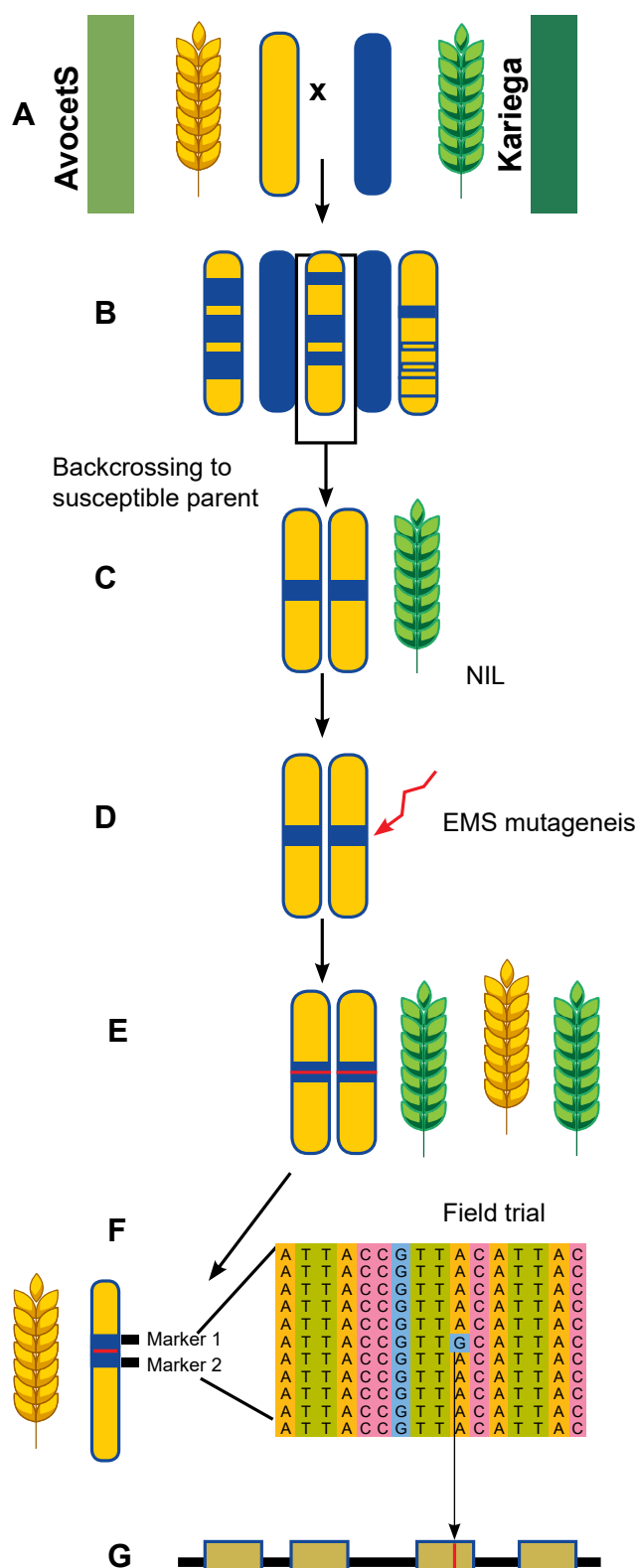


Figure 2: A-G: A brief overview of the gene cloning process involved in cloning Yr27 in Kariëga

green leaf tissue (Figure 2A – yellow chromosome). This cultivar (Kariëga) was developed in South Africa and was used as the baking standard for years.

The next step is to select a cultivar known to be susceptible to the same disease, visually seen as leaves turning more yellow (Figure 2A - blue chromosome). It can be assumed

that within the genetic makeup of the resistant and susceptible cultivars lies the reason for their respective phenotypes. However, getting to the root cause of this resistance on a genetic level is a complex task. The initial crossing of the resistant parent plant to the susceptible parent plant (Figure 2A) allows for the genotype/phenotype association to be studied (Figure 2B). The question asked at this point is: "In the offspring of this cross, is there a correlation between genomic regions inherited from the resistant parent and the phenotype of those offspring?"

Once a line can be identified that carries a genomic region of interest from the resistant parent (Figure 2B – black box) which is correlating to a resistance phenotype, it is ideal to have only this segment of DNA from the resistant parent present to ensure that other elements of the genome are not conferring resistance. Repetitive backcrossing of this selected line to the susceptible parent allows for the development of a Near Isogenic Line (NIL) (Figure 2C). This is a line that contains the genetic background of the susceptible parent, but the genomic region of interest from the resistant parent.

The simplest way to prove that the region of interest (inherited from the resistant parent) is responsible for the observed resistance, is to 'inactivate' the region and show that the same line loses its resistance. An easy way of doing this is through applying a chemical mutagen onto the seed of this line and relying on the possibility that a mutation will occur in the gene of interest (Figure 2D). The possibility of obtaining a mutation within the gene of interest is very low and therefore large mutant populations have to be constructed and screened for their loss of function in that disease resistant phenotype (Figure 2E).

The nature of the mutations inflicted by the chemical treatment is that of Single Nucleotide Polymorphisms (SNPs), or single base-pair changes within a DNA sequence (Figure 2F). By extracting DNA from these mutagenised plants that have lost their resistant phenotype, sequencing the region of interest and using bioinformatic analyses to compare the sequence of the mutants to the non-mutants, it becomes clear where these SNP's lie. In theory, this pinpoints a genomic location of the gene of interest (Figure 2G). Once the location and exact DNA sequence of this gene can be identified, we refer to the gene as being cloned.

Why is this type of research important to South African farmers, researchers, and the next generation of South African scientists?

South African wheat consumption has been increasing for decades now (Figure 3), with farmers working hard to ensure our population maintains access to the cereal that allows for the production of pasta, bread, pizza, animal feed and many other staple items. There are many realistic circumstances that can threaten our access to these beloved carbohydrates. Many factors, imposed by humans or by nature itself, can threaten the livelihood of the cereals

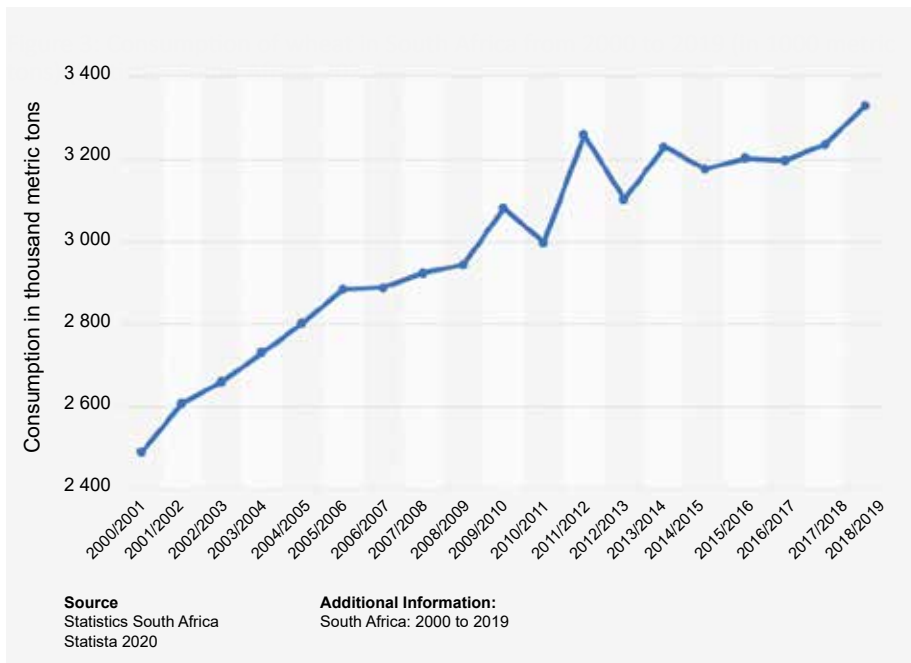


Figure 3: Consumption of wheat in South Africa from 2000 to 2019 (in 1000 metric tons) (Statistics South Africa, 2020).

data from the few wheat genomes that are publicly available, most of which, such as Chinese Spring, are far removed from our South African breeding material. Now, instead of relying on wheat genomes of cultivars that are very distantly related to South African breeding material, and conferring these 'foreign' results onto the cultivars we breed in South Africa, we can look directly at the genome of a South African cultivar.

As genome sequencing and the possibilities that it brings to light for crop improvement progress, it is important that South African researchers work hard to remain involved in the collaborations demonstrated. It is becoming increasingly obvious how easily third world countries can fall behind in the progression of genomic research due to a lack of funds and resources

we grow. These are known as biotic or abiotic stressors, which can be fungal or bacterial diseases that infect the plant or excessive drought, respectively. As showcased with the recent drought period from 2018-2022, or the invasion of a multitude of devastating fungal pathogens such as Ug99 stem rust, South Africa is not isolated from possible devastation when it comes to our cereal crops.


So, what are we doing to ensure the livelihood of our crops? One way is to study the genetics of the plants to ensure that within them, they have the genetic makeup that will allow them to be resistant to invading pathogens.

These genetic components that are responsible for resistance to these pathogens are known as resistance genes. Some plants have evolved to naturally contain resistance genes. In wheat, for example, only 26 rust disease-resistance genes have been cloned between 2003 and 2020.

Before the sequencing of the Kariiega genome, South African wheat researchers relied on genomic sequence

in developing countries. In South Africa, biotechnology, biology and data science are already considered a 'critical skill', and it is the hope of companies such as CenGen that more young students develop a passion for these fields of research.

The Kariiega genome itself is published as a freely available resource, which scientists worldwide are already utilising. The knowledge generated from this genome will feed into South Africa's wheat breeding programs, and can accelerate the rate at which we discover genes that can increase the producers yield, be it through identifying novel disease-resistance genes, drought-tolerance genes or grain quality related genes. CenGen's ultimate goal is to give back to those farmers who see value in the genetics of their crops, and supporting South African farmers in producing world-class wheat.

Article by Shannon Derman , wheat research scientist for CenGen. The author can provide a full list of references on request.

Uma ososayenci base ningizimi Afrika bethuthukisa izakhi zofuzo zikakolo, benza ukuthi ukolo iqine ukwazi ukukhula noma kunesomiso, kushisa kakhulu, kunamazi amaningi, noma uhlaselwa izinambuzane, kubuye kwenze ube nomsoco kakhulu kunyuse ukudla ezweni.

Translated by Zamantimande Kunene

The journey of a young science communicator

Letago Kgomoewana was not always planning to work in the climate change field but now she is building climate change resilience with the people for the people.

Like all postgraduate students, Letago had a lot on her plate. She had meetings to set up with local farmers in the Mopani district in Limpopo to collect qualitative data for her research project. She had papers to read, a thesis to write, and all the regular demands on the time of a young environmental geographer.

So, when Dr Sheldon Strydom, senior lecturer in Geography and Environmental Studies at the North-West University, encouraged Letago, his student, to enter the FameLab 2021 competition, she was hesitant.

Little did she know that in less than a year she would be representing South Africa as one of the top young science communicators in the world, meeting international researchers, and sharing with the world her passion to see indigenous knowledge systems considered in improving our climate resilience.



Letago Kgomoewana from FameLab. FameLab is well known for the quirky props used by young researchers to explain scientific concepts with clarity and charisma in a way that a general audience could understand and enjoy.

Letago Kgomoewana was not always planning to work in the climate change field. But her interest in climate change resilience was sparked during her honours degree year when she learnt about climate change-related extreme events and disasters.

Combined with her home-grown experience and background in agriculture, this led the way to her current master's degree project that looks into the use of indigenous knowledge systems and their potential to be included in disaster risk management strategies and climate change mitigation policies.

In her time spent with local communities, Letago quickly realised that no one understands an environment like the people who live and work in it. Letago is passionate about encouraging science and scientists to acknowledge the importance of indigenous knowledge and adding the voice of the public, who Letago sees as "libraries of indigenous knowledge" to the climate change conversation. And it was this passion that made Letago stand out during the FameLab SA 2021 competition.

"As someone who was completely unaware of FameLab and science communication prior to entering FameLab, the competition provided me with a series of firsts. It gave me an opportunity to talk about my scientific research outside of my department at North-West University. As a scientist, it opened my mind to a whole world of like-minded and passionate people who want to use their science to change the world," says Letago.

After winning the local FameLab heat held at the North-West University, Letago joined a group of talented young researchers from universities and research institutes across the country to hone their science communication skills and compete in the national competition.

In October 2021, Letago came first in the FameLab SA 2021 final. As part of her award, she would attend an international

FameLab, also nicknamed the 'Pop Idols' of the science world, is a global science communication competition that gives young scientists the chance to present their research in an entertaining and engaging way to a general audience. In South Africa, FameLab is run by the South African Agency for Science and Technology Advancement and Jive Media Africa, a company that specialises in science communication training. One of the benefits of this competition is the opportunity it offers to contestants to improve their science communication, public engagement and presentation skills through the various workshops contestants attend during their FameLab journey.

science communication masterclass and go on to represent South Africa alongside national winners from 23 different countries in the international FameLab competition.

All the training and practice paid off as Letago was voted one of the FameLab 2021 international top 10 finalists. During the online international final, Letago impressed the judges with her storytelling talent and, to the delight of her enthusiastic #teamletago supporters, Letago was awarded the position of first runner-up.

In her three-minute talk, Letago shared some of the knowledge held by local farmers on how to deal with the challenges of a changing climate and what science can learn from them. "This finalist hooked us in right from the start and displayed an absolute passion for her subject. She showed us how something quite unexpected can be one of the global solutions to one of the most pressing problems we face," said panel judge Dr Tara Shine, an environmental scientist and policy advisor.

Virologist Alex Cloherty from the Netherlands claimed the title of FameLab International 2021 Winner. She compared the immune system to a game of chess, while Samantha Nixon from Australia thrilled audiences with her research about using spider venom to treat sheep parasites, securing her the second runner-up spot.

Letago feels that the FameLab experience exceeded all her expectations, building her as a scientist and individual. "I hope that my journey to the world stage inspires a new generation of bold, young researchers who will take up careers in science and technology, research and science communication.

"Indigenous knowledge, although previously viewed as inferior to scientific knowledge, is proving to be just as effective as the latter. Indigenous communities have not always gained from advances in science and technology, especially where risk reduction is involved. As a result, indigenous people have over the years come up with ideas, applied them and maintained knowledge bases to assist them with disaster risk reduction," says Letago.

Since her work with indigenous knowledge began, Letago has found it a reliable source of knowledge because it has so many references. "A method cannot be used for over 50 years without some proof that it is effective. Indigenous people have sustained their livelihoods for generations." Letago believes that conversations around sustainability should include indigenous and cultural knowledge.

Her research uncovered some of the many methods used by Limpopo farmers to adapt to the impact of climate change. Farmers use creeper crops, such as watermelon, pumpkin



FameLab takes participants on a journey of personal development through training and experience in science communication, public engagement and presentation skills.

and sweet potato, to control weeds and maintain soil moisture levels. The *ronjo* system, a traditional method of dividing the village into pasture zones, helps to conserve pastureland and prevent drought-borne disasters. The behaviour of insects and other animals, such as locusts, snakes, butterflies and bees, are carefully observed as indicators of approaching droughts.

As a scientist, science communicator and indigenous knowledge systems advocate, Letago believes that no single form of knowledge, scientific or other, can be a catalyst of change on its own. Her advice to young people who hope to pursue a career in science is to engage in science programmes from an early age to explore the different fields of science and find their niche.

"From Science Olympiads in schools and the Eskom Expo for Young Scientists all the way to FameLab, there are so many opportunities to put yourself out there and begin to establish yourself as a young scientist. African science is fast-growing and our research is having valuable global impact, which is why this generation of up-and-coming scientists is so important."

Article prepared by Jive Media Africa (www.jivemedias.co.za).

If you would like to participate in FameLab or host a heat as part of the national competition, please contact:
famelab@jivemedias.co.za



Air pollution in South Africa

Why are the 2021 World Health Organization Air Quality Guidelines important?

What is air pollution?

Air pollution is any chemical, physical, or biological agent that changes the air around us. Examples are chemical fumes coming from cleaning products, small pieces of metal or dust suspended in the air or even pollen coming from trees. Smoke caused by wildfires is also air pollution.

When inhaled, many air pollutants cause serious health problems, such as respiratory or even cardiovascular illnesses. Poor air quality kills about 7 million people across the globe every year. Air pollution is particularly bad in cities, where many people live and where traffic is bad, or in industrial hubs, where factories and power stations pollute the air we breathe.

In South Africa, many people rely on coal- or wood burning to heat and cook. The smoke created by this burning process causes air pollution inside people's homes. About 2.6 billion people around the world rely on polluting cooking systems, and this is a big health problem.

What are the health impacts of air pollution?

Air pollution affects our health differently, depending on how much time we spend breathing in a specific pollutant, how high the levels (or concentration) of the pollutants are, and what the pollutants are made of (heavy metals, for example).

People most at risk from breathing polluted air are children (because their lungs are still developing), the sick (people who already have lung diseases like asthma), and the elderly. Impacts from breathing in polluted air are, for example, coughing, sore or scratchy throats, inflamed airways, decreased lung function, irregular heartbeats, nonfatal heart attacks, and even premature death in people with heart or lung disease.

What is air pollution like in South Africa and how do we manage it?

South Africa has many sources of air pollution. Some of the main pollution sources are:

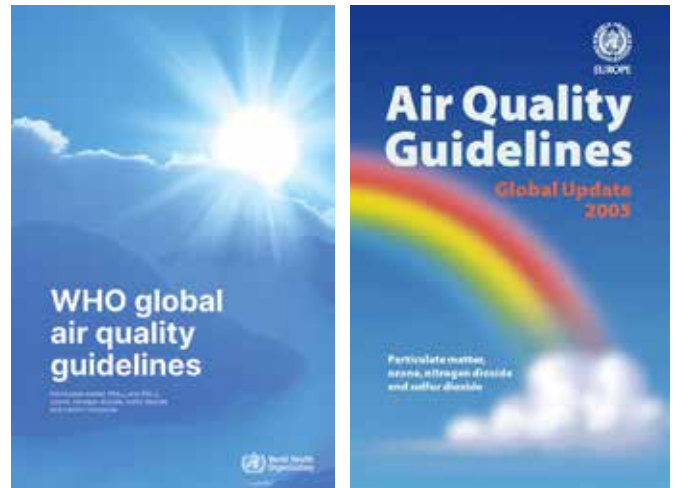
- Vehicle emissions, especially in cities
- Waste burning, especially in informal communities
- Industrial activities in industrial hubs
- Mining for coal and other resources
- Power generation at our coal-fired power stations
- Domestic burning in low-income households for cooking and heating
- Sand and dust storms

The Department of Environment, Forestry and Fisheries declared three Air Quality Priority Areas in the country, where many industrial activities (like power generation or mining) emit tons of pollutants into the air every single year, causing high pollution levels on the ground impacting on humans and the environment.

To make sure that the air that people breathe on the ground is not harmful to their health, South Africa has put in place **National Ambient Air Quality Standards (NAAQS)**. The NAAQS regulations govern which levels of pollution are deemed safe to breathe or not. Different air pollutants have different standards, which are represented by specific limit values. When these limit values are exceeded, the air is considered unsafe to breathe.

Who is the World Health Organization and what are the new Air Quality Guidelines all about?

The World Health Organization (WHO) is a special agency, which forms part of the United Nations and which is responsible for international health issues or public health. The WHO guides the world in how to control and manage diseases (like COVID-19). Because air pollution contributes to millions of deaths, the WHO developed **Air Quality Guidelines (AQGs)** using latest scientific evidence. The WHO AQGs help countries reduce air pollution levels in a step-by-step manner by using 'interim targets' (IT-1, IT-2, IT-3, IT-4).

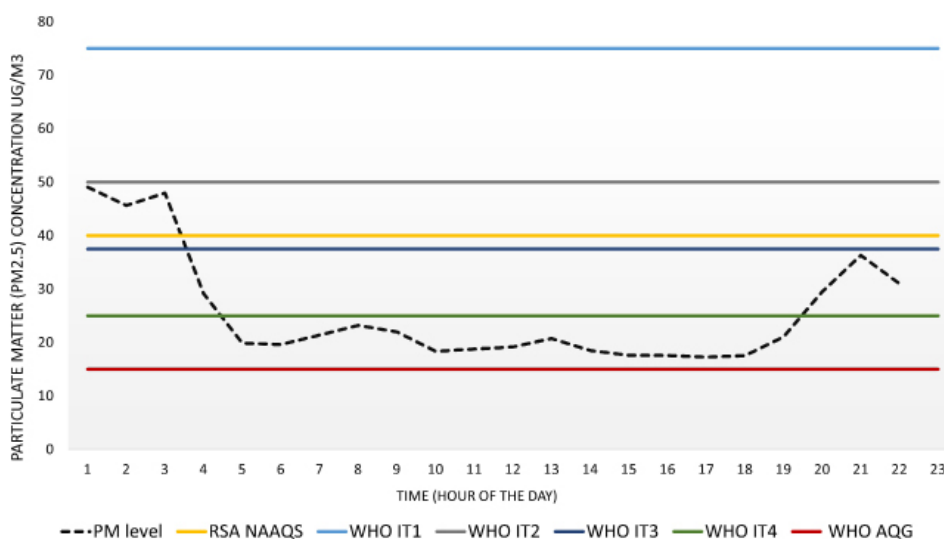


In September 2021 the new AQGs (left) were released, updating the old AQGs from 2005 (right). The full World Health Organization Air Quality Guidelines 2021 report is available online: <https://apps.who.int/iris/handle/10665/345329>

Why should South Africa seriously consider the new WHO AQGs?

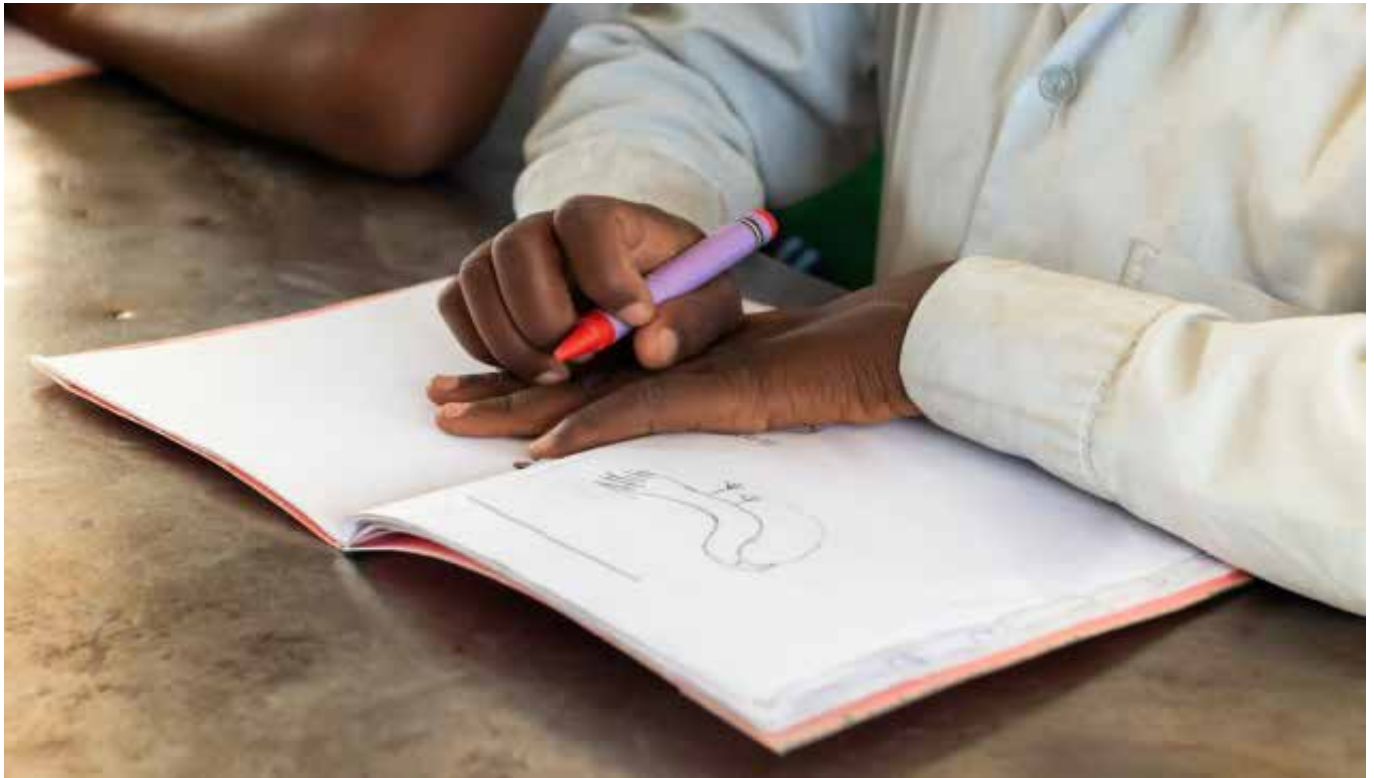
South Africa has air quality management plans in place to ensure that air pollution is managed to stay below the NAAQS values. However, our NAAQS may not be strict enough to protect human health. South Africa is reviewing its NAAQS and will probably use the ITs as stepping stones to bring air pollution levels down. Some companies will have to install equipment to reduce the pollution they emit. Households need electricity so they can live in a healthy environment.

Bianca Wernecke ^{ORCID} and Caradee Y Wright ^{ORCID} are research scientists in the Environment and Health Research Unit at the South African Medical Research Council.



Hourly PM_{2.5} concentrations measured in Alexandra, Johannesburg on 3 December 2021

The NAAQS vs the AQGs using particulate matter pollution (PM_{2.5}, which represents particles with an aerodynamic diameter of less than 2.5 microns) on one day in Alexandra, Johannesburg. The current daily NAAQS lies between the WHO IT-2 and IT-3 target values. The hourly pollution levels fluctuate between different target values throughout the day. The pollution levels are mostly considered safe to breathe according to the South African NAAQS, but not according to the WHO AQGs.



The “How to Get Ahead During and After School” Series

Part 1 – Making Good Decisions in Grade 9

Introduction

The magazine called *Science Matters*, published by the National Research Foundation of South Africa, featured an article about youth unemployment being high in South Africa. The article said that one of the possible reasons is a lack of information given to learners on how to make decisions about their future. Two points were made: there is not enough guidance at school about subject and career choices; and finding out about jobs or further education opportunities can be difficult.

In response to that article, Quest will present four parts in a series called ‘How to Get Ahead During and After School’. In 2022, one part will be included in each of the four issues of Quest.

Part 1 will focus on subject choices in Grade 9, resources available to help with making subject choices, and the need for career counselling (plus how to find it). Part 2 will look at the Grade 11 year. It will give some suggested do’s and don’ts for tertiary education applications, and explain the difference between universities and Technical and Vocational Education and Training (TVET) institutions, how to fill in application forms (the importance of honesty and completeness), and study techniques. Part 3 will consider the Grade 12 year, focus on study techniques, whether to take a gap year after school and how to prepare a curriculum vitae (CV). The final part will look at the first year after school. It will cover topics such as: ‘you didn’t get accepted, now what?’; should you pursue part-time work, full-time work or study; study options; and succeeding in your first year of tertiary education.

From *Science Matters* Vol 4 Issue 2 of 2022 - ‘Exploring the Intractability of Youth Unemployment in South Africa. Why is the problem of youth unemployment in South Africa so difficult to solve?’

“....the youth (15 to 34 years) unemployment rate remains high.”

Micro level factors affecting this include:

- Lack of information
 - Schools offer little career guidance, leading to youth lacking information on matching skills and interests to their chosen school subjects.
 - Information on how to apply for a job, compile a CV or access further education opportunities is in short supply.
- Lack of work experience
 - Part-time employment during school or while studying impacts positively on employment prospects.

Part 1 – Making Good Decisions in Grade 9

Grade 9 is a fun but challenging year because you need to decide which subjects you will take in Grade 10. Making subject choices is important. If you decide and choose well, you will enjoy your subjects and you will have options for different careers or for studying further.

School subjects have different learning activities, such as reading, writing, practical work, laboratory work, fieldwork, etc. Some subjects, such as Accounting, Business Studies, Mathematics, and History, are mainly theoretical. Other subjects, such as Graphics and Design, Music, Visual Arts, Dance Studies, and Dramatic Arts, have a large portion of practice work. Computer Applications Technology and Information Technology require a lot of time spent on computers. Life Sciences and Physical Sciences usually have laboratory work or field trips and need good analytical, reasoning and critical thinking skills.

The subjects you choose will demand certain skills from you and will also help you to develop new skills. Good language and writing skills are important for Business Studies, Economics and History, for example. Creative and practical abilities are needed for subjects like Music, Dramatic Arts, Design and Visual Arts. Some subjects, like Geography, Religion Studies and Consumer Studies, need good memorisation skills and comprehension skills.

Do's and don'ts for making your subject choice a good one:

- Do choose subjects you enjoy.
- Don't choose a subject that does not suit your abilities.
- Do choose subjects that you need for entry into a study programme after school.
- Don't choose a subject because your teacher says so, or because your friends are taking it.
- Do try to think of possible jobs or careers you might like to do one day.
- Don't choose a subject because you like the teacher; they might leave!

What is career counselling?

Career counselling helps you choose a career by understanding who you are, your skills and interests, and using different types

Useful websites to help you make subject choices

- <https://www.abassessments.co.za/the-importance-of-grade-9-subject-choice>
- <https://www.news24.com/parent/learn/learning-difficulties/grade-9-subject-choices-why-you-should-start-considering-them-now-20210406>
- <https://www.iie.ac.za/grade-9-subject-choices-why-you-should-start-considering-them-now>
- <https://www.careerhelp.org.za/main/career-development-services>
- <https://www.advtech.co.za/grade-9-subject-choices>
- <https://self-directed-search.com/>
- <https://cozacares.co.za/>

of assessments to guide you when you make subject and career decisions. Sometimes schools have a pastoral care teacher who can give career advice; some schools may have a career advisor. There are also companies advertised on the Internet that can assist you (for a fee) with these decisions by asking you questions and using your results to suggest good career matches. Careers are fun and fulfilling when they involve work that interests you and you enjoy doing. A good way to find out about different careers is to talk to people in a career that interests you — maybe a friend's parent, for example. It is also important to remember that you can change your mind about what career you might like to do; but be sure to choose subjects wisely so you have these options later on.

Where is the topic covered in the South African National Curriculum?

Topic: World of work

Grade 7

- Importance of reading and studying • Career fields • Simulation of career-related activities
- Value and importance of work in fulfilling personal needs and potential

Grade 8

- Different learning styles • Six career categories • Relationship between performance in school subjects and interests and abilities • Decision-making process

Grade 9

- Time-management skills • Reading and writing for different purposes • Options available after completing school • Knowledge of the world of work • Career and subject choices • Study and career funding providers • Plan for own lifelong learning

Topic: Careers and career choices

Grade 10

- Subjects, career fields and study choices • Decision-making skills • Socio-economic factors • Diversity of jobs • Opportunities within career fields • Trends and demands in the job market • The need for lifelong learning.

Grade 11

- Requirements for admission to higher education institutions • Options for financial assistance for further studies • Competencies, abilities and ethics required for a career • Personal expectations in relation to job or career of interest • Knowledge about self in relation to the demands of the world of work and socioeconomic conditions.

Grade 12

- Commitment to a decision taken • Locate appropriate work or study opportunities in various sources • Reasons for and impact of unemployment and innovative solutions to counteract unemployment • Core elements of a job contract • Refinement of portfolio of plans for life after school

South Africa: Are we making any progress?

Tsepo Majake from the Academy of Science of South Africa considers whether we are on track as a country to meet education goals and our National Development Plan.

There are 17 Sustainable Development Goals (SDG) that one might argue can only be attained through the support of science (Figure 1).

The first two SDGs are to alleviate poverty and remove hunger. A country needs a sound plan that is supported by research and strongly embedded in the available resources of that particular country to achieve these SDGs.

The African continent, for instance, would need a strong agrarian (or agriculture), energy and mineral research plan and system to achieve these first two SDGs.

Let's consider how these two SDGs show how science can support and assist in achieving them.

In the South African context, the SDGs are interpreted through the National Development Plan (known as the NDP), which is the blueprint of the economy. **Figure 2** shows the National Development Plan and how it is packaged as goals to be achieved at the national level.

Meeting the NDP goals require a strong scientific approach if they are to be achieved in the next few years. For example, to alleviate poverty, create jobs, ensure



Figure 1: Sustainable Development Goals

spatial development, fight crime and so on, we need data, information and the adoption of evidence-based approaches to problem solving.

Are we as a country making headway to ensure that we are well prepared for the attainment of these goals at national (NDP) and global (SGD) levels?



Fig 2: National Development Plan 2030

Focussing on basic education, we can use high school results as a yard stick.

The national Grade 12 results have been steadily improving over the last six years from 2015 to 2021.

Table 1 shows an improvement in Grade 12 pass percentages from 2016 to 2021.

The discourse around the South African Grade 12 results has often been problematic with calls to increase the pass mark, force certain subject choices and subject combinations. There have also been resource and infrastructure challenges (like not enough textbooks) and concerns about the number of learners registered from grade 1 making it through grade 12.

If we focus on the number of university entrants, we can see that it has been steadily increasing for the last six years (**Table 2**).

If we look closely at learner percentage passes in the science subjects from 2016 to 2021, there is a downward trend in some subjects. This is an area for improvement.

Table 3 below shows learner attainment in key science subject at 30% from 2016 to 2021.

There are other yardsticks that can be used to measure if we are making headway to prepare for the attainment of the NDP and SDGs in the education sector, like the 'Trends in International Mathematics and Science Study (TIMMs) and The Southern and Eastern Africa Consortium for Monitoring Educational Quality (SAQMEQ) standardised tests.

Here, we focus on the national examination results that decide whether learners will enter higher education institutions and go on to help a South Africa that can meet the SDGs.

Table 4: Number and percentage of distinctions in the five key science subjects (Source: 2020 examination report 2019, 2020, 2021)

In conclusion, as a country we need to bring our resources together to improve our national Grade 12 results. While the achievement of learners at school is the responsibility of the Basic Education Department, all sectors of society (and especially the sciences) can assist to ensure a better and greater output.

The question to ask is 'how can we cooperate in improving our high school results, and consequently bolstering our ability to achieve our NDP and SDG targets?

Table 1: Grade 12 pass percentages from 2016 to 2021 (Source: 2020 examination report 2019, 2020, 2021)

Year	2016	2017	2018	2019	2020	2021
National pass %	72.5	75.1	78.2	81.3	76.2	76.4

Table 2: Grade 12 bachelor pass percentages from 2016 to 2021 (Source: 2020 examination report 2019, 2020, 2021)

Year	2016	2017	2018	2019	2020	2021
Bachelor % passes	26.6	28.7	33.6	36.9	36.4	36.4

Table 3: Grade 12 subject percentage passes at 30% from 2016 to 2021 (Source: 2020 examination report 2019, 2020, 2021)

	2016	2017	2018	2019	2020	2021
Agricultural science	75.4	70.4	69.9	74.6	72.7	75.4
Geography	76.5	76.9	74.2	80.5	75.3	74.3
Life Sciences	70.5	74.4	76.3	72.3	71.0	71.5
Mathematics	51.1	51.9	58.0	54.6	53.8	57.6
Physical Sciences	62.0	65.1	74.2	75.5	65.8	69.0

Table 4 shows how learners are performing in the five-science subject with distinction (marks of 80 - 100%) in the last two years.

	2020			2021		
Subject	Wrote	Achieved at 80-100%	% Pass	Wrote	Achieved at 80-100%	% Pass
Agricultural Sciences	96 155	786	0.8	123 990	1469	1.2
Geography	287 629	2755	1.0	358 655	1911	0.5
Life Sciences	319 228	7 317	2.3	384 216	14 310	3.7
Mathematics	233 315	7 424	3.2	259 143	7 725	3.0
Physical Sciences	174 310	6 368	3.7	196 968	6 771	3.4



Space travel and the human immune system

Are we ready to travel to Mars? A new study, called INVEST, funded by the National Research Foundation (NRF) and Belgian Federal Science Policy Office (BELSPO) examines if humans could survive long-duration space travel.

At the moment, space radiation is a potential showstopper for future manned space missions, since an astronaut on a mission to Mars would receive radiation doses up to 700 times higher than on Earth. A new study investigates the effects of space radiation on the human immune system. Dr Randall Fisher, a postdoctoral researcher in Space Radiobiology working in the Radiation Biophysics division at NRF-iThemba LABS, is leading a team of scientists who are studying how the human immune system, which is highly

sensitive to both psychological and physical stressors, would react to extended space travel-related neutron radiation, an important secondary component produced by space radiation.

Comprised mainly of galactic cosmic rays and solar energetic particles, space radiation differs from the radiation types (e.g. X-rays) we normally encounter on Earth. It has a greater ionising effect that can cause



considerable damage to human DNA. In addition, its potent ability to disrupt atoms enables it to produce secondary particles when it impacts spacecraft shielding or astronauts' bodies. This phenomenon, called 'spallation', produces a more-dangerous neutron radiation field inside the spacecraft.

It is challenging and costly to study the health effects of space radiation in space, and ground-based experimental analogues are an achievable alternative for researchers with access to a particle accelerator. This requirement paints NRF-iThemba LABS as a niche facility to conduct space life sciences experiments in Africa and forms the rationale behind the INVEST collaborative, whose aim is to establish a ground-based *in vitro* model to study space health effects. Dr Fisher's pilot study in the INVEST collaborative examined the immune effects of low doses and dose rates of spaceflight-related high-energy neutrons.

What did they do?

The effect of neutron dose rate on immune alterations was studied using the *in vitro* cytokine release assay. Blood samples from healthy adult volunteers were exposed to 0.125Gy or 1Gy of neutron radiation, administered at a 0.015Gy/min (lower dose rate or LDR) or a 0.4Gy/min dose rate (higher dose rate or HDR). The unit Gray (Gy) refers to the absorbed radiation dose that's typically 0.7 mGy for an abdominal X-ray and as high as 80 Gy in radiotherapy applications. After irradiation, immune cells in the blood were stimulated with Pokeweed Mitogen (PWM) or bacterial antigens before being incubated for 24 hours.

Interleukin-2 (IL-2), interferon-gamma (IFN- γ), tumour necrosis factor-alpha (TNF- α), and interleukin-10 (IL-10) are soluble signalling molecules or cytokines, secreted by immune cells to coordinate immune system functioning. Plasma concentrations of these cytokines were measured and correlated to the neutron dose rate and stimulant treatment administered. Stimulants generally increased all plasma cytokine levels except IL-2, where only PWM induced a significant increase.

What did they find?

In general, no statistically significant changes were observed in IL-2, IFN- γ , and TNF- α concentrations at different neutron doses and dose rates when compared to their controls. After PWM-stimulation, IL-10 levels were significantly increased after 0.125Gy HDR and 1Gy LDR neutron treatments. Pooled-per-dose rate data showed that the HDR significantly increased IL-2 titres (under PWM-stimulation) and IFN- γ titres (with all stimulants), but significantly decreased TNF- α secretion in unstimulated samples.

Their findings suggest that neutron irradiation on a deep space mission may suppress the astronaut's immune system through the over-secretion of IL-10 (an anti-inflammatory cytokine) and that the dose rate plays an important role in IL-2 and TNF- α suppression, which may prevent efficient immune response to viral infections. Dr Fisher and his team are continuing this research and plan to incorporate simulated stress and simulated microgravity as spaceflight stressors into future experiments.

First published in NRF Science Matters, Volume 4, Issue 2, available at <https://www.nrf.ac.za/science-matters-magazine/>. Republished with permission.

Sesikulungele ukuya emkhathini ku Mars? Ibizwa nge INVEST, ixhaswe I National Research Foundation (NRF) and Belgian Federal Science Policy Office (BELSPO) ihlola ukuthi abantu banga phila emkhathini isikhathi eside.

Translated by Zamantimande Kunene



Extreme weather in remote places: Snowfall in the Sahara

Despite being the one of the world's hottest deserts, the Sahara experiences different types of extreme weather. Temperatures of over 50°C have been recorded within the desert itself, and these are important for breaking down rocks by thermal weathering and contributing to the generation of loose sand. Temperatures as low as -14°C have also been recorded in the mountains of the Algerian Sahara, and these too can contribute to rock breakdown by frost shattering processes. By contrast, rainfall can also be highly variable – central parts of the Sahara are hyperarid, receiving less than 100 mm of rainfall per year. Areas such as the Gilf Kebir of SW Egypt have an annual average rainfall of less than 5 mm and experience no rain for years, possibly decades. But then sudden and extreme rainstorms can bring tens of millimetres of rain over a few hours, triggering flash floods and rapid land surface change within reactivated wadi channels.

Although uncommon, snowfall in the Sahara can also take place, most recently in January 2022. Snow requires both low atmospheric temperatures and moist air and thus reflects an unusual combination of weather conditions. Moist air comes into the Sahara from low pressure cells

(cyclones) developed over the surrounding water bodies of the Atlantic Ocean (to the west) and the Mediterranean Sea (to the north). The proximity of these water-source areas means that the margins of the Sahara (in particular the north) are wetter than more inland areas. A key factor triggering rainfall (or snowfall, if air temperatures are low enough) is the presence of mountains near to the coast. This is because, as air rises over higher ground, it can cool, condense and form clouds from which rainfall can take place, giving rise to flooding in lowland areas adjacent to these mountains. If the air temperature is low enough, snowfall can take place over the mountains and in areas immediately inland. The most common snowfall events, and the greatest snow depths when such events occur, are found in the Anti Atlas range of southern Morocco, and Saharan Atlas range of NW Algeria. In the Anti Atlas are found the region's few ski resorts (supplemented by machine-made snow), and in the Saharan Atlas near the town of Aïn Séfra, blizzards have been recorded several times in recent decades, resulting in roads being closed and communities cut off. The snowfall in this region in January 2022 was not a one-off event but part of a repeated winter pattern taking place when the air and

land surface are both cold, allowing snow to fall and then to settle (for at least a few days). Remote sensing technologies can give greater insight into the timing and spatial patterns of snowfall across the Sahara, and this may help identify the effects of climate change or weather patterns on snowfall climatology. Satellite radar technology can be used to accurately map rainfall patterns, and hyperspectral satellite imagery to map soil moisture and land surface temperatures. These are significant advancements in understanding weather and climate in the Sahara and similar remote areas.

The role of climate change


The Sahara Desert is commonly viewed as being hot and dry all the time, and thus an unlikely place to examine the effects of climate change. However, the Saharan climate is actually quite variable and can include both periods and locations where cold temperatures, high event-scale rainfall and even snow are recorded. In part, this variability is because the Sahara is a very big place, covering over 9 million km² and with environments extending across a latitudinal range of some 15 degrees (equivalent to the range between Durban and Lusaka). It also reflects the different directions from which weather systems are derived – west, from the Atlantic Ocean; north, from the

Mediterranean Sea; and east from the Red Sea. Monsoon rainfall patterns and seasonal harmattan winds also affect

some parts of the Sahara. Climate change influences the large-scale patterns of atmospheric circulation that bring seasonal rainfall into the wetter margins of the Sahara, and as such may influence the position of the intertropical convergence zone and the timing and strength of the West African monsoon. In theory, such weather patterns can be used to identify the fingerprint of climate change in the Sahara; but in reality there is a lack of long-term instrumental weather records in the region to track any climate changes, so such a link cannot yet be made.

Despite this, it is interesting to look at extreme weather events (e.g. heatwaves, cold snaps, rainfall leading to flash floods) because climate models show that these events will increase in frequency and magnitude under global climate change. Snowfall across the Sahara can be considered as an extreme event because it takes place relatively uncommonly and reflects both cold atmospheric temperatures and moist air being present. Snow has been recorded several times in the Sahara Desert over recent decades, most recently in January 2022, and can settle for several days when the land surface is also cold. The NW Algerian town of Aïn Séfra is particularly affected by snow events, receiving snow in the winters of 1979, 2016, 2017, 2018, 2021 and 2022. This latter event was just a light dusting, whereas in 2018 up to 30 cm of snow fell over higher ground. Several times, historically, snowfall has closed roads in this region. It is unclear from climate models or from historical records whether snowfall events are changing in their timing, frequency or distribution in the Sahara – there is just not enough data. But extreme weather events as hazards in the Sahara should not be underestimated. Heatwaves and floods can also be made worse by human activity including urban growth,

agriculture, and over-exploitation of groundwater resources. Climate change is already drying out the wetter margins of the Sahara, and the desert itself is getting bigger. In turn, this will make weather extremes more widespread. We do not yet have a full understanding of the range of weather extremes present in the Sahara, or their impacts, but this is needed if impacts of extremes like snowfall on local communities are to be successfully mitigated.

Written by Jasper Knight 
Professor of Physical Geography
University of the Witwatersrand,
Johannesburg, South Africa



The participation of earth scientists and geologists in the migration from fossil fuels to green energy over the next half century is fundamental to the sustainability of humanity. The transition will require earth scientists in a multitude of roles, from discovering and mining critical metals necessary for renewable energy to documenting climate change effects on earth systems.

The Geological Society of South Africa is proud to have supported geologists and earth scientists throughout southern Africa since 1895, and will continue to do so as the world seeks a carbon-neutral and sustainable future.



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What does it mean to be an environmental health campaigner?



Quest interviews Rico Euripidou from the non-governmental organisation, groundWork, to find out more.

1. groundWork is a non-governmental organisation (NGO). What does that mean?

Being an NGO means that we are an organisation that is not part of government. We are part of civil society. To be an NGO allows us to maintain our values and integrity, show our donors how the money they give us is spent, and work in such a way that does not make a profit. All our funds support our work. And yes, I do get paid a salary to do my job.

2. Why did you decide to work for groundWork?

groundWork gives me the freedom and space to articulate all the things in life that matter to me when it comes to environmental health. Working for an NGO allows us to develop our own areas of interest and then advocate for environmental problems and issues in that space. For example, one of my interests is preventing people from being exposed to mercury in the environment. groundWork gave me the opportunity to do that.

3. What is the purpose of groundWork?

groundWork is a non-profit, environmental justice service and developmental organisation working primarily in southern Africa. It works in the areas of climate and energy justice, coal and a just transition to clean energy, environmental health, global green and healthy hospitals, and waste. groundWork is the South African member of Health Care Without Harm and Friends of the Earth International.

An important mission for groundWork is to advocate for vulnerable people. Vulnerable people are people who have not had all the structural factors that support healthy, productive individuals. For example, a child living in a township may not have the opportunity to attend a good school with all the facilities and resources, compared to a child living in a suburb who attends a school that has up-to-date facilities and resources and maybe even a fully operational science laboratory.

Moreover, the child living in the township may be exposed to more environmental factors that affect health, such as air and water pollution from nearby mining activities.

All of these factors lead to inequality and one child being more vulnerable to getting sick from pollution or not getting a sound education compared to another living somewhere else. groundWork strives to resolve structural and other reasons that lead to vulnerable people.

4. What is one of groundWork's greatest success stories?

To advocate for people living in a highly polluted area of South Africa, groundWork embarked on a campaign called 'The Deadly Air Case'. Even though South Africa has a very good constitution (Section 24 talks about the right to a healthy environment) and laws that serve to protect people and the environment from air pollution, often these rules are not properly put in place to make sure people are safe.

'The Deadly Air Case' has taken a special approach to focus on the rights of vulnerable people such as children and young people. In May 2021, after preparing a lot of reports and working with lawyers, groundWork went to court to lodge a case that children living in the Highveld area of South Africa are disproportionately affected by air pollution. In this first of its kind case in South Africa, the judge ruled in favour of groundWork and others in a landmark ruling that will help reduce air pollution and save lives.

5. What kind of training prepared you for working at groundWork?

In terms of formal training, I did an environmental science degree but then I realised I wanted to learn more about environmental health, so I did an environmental health degree too. Environmental

What is environmental justice?

Environmental justice is about addressing inequality. The people who are most responsible for causing pollution, whether they are nations or corporations, companies, or industries, are generally least affected by the pollution and sometimes the least responsible for fixing the pollution problem. The people most affected by the pollution problem are usually the people least responsible for causing it, with the least number of resources and agency to do something about the problem. That's where environmental justice comes about – NGOs like groundWork stand up for those people affected the most by the pollution to ensure polluters are held responsible for the pollution they cause.

epidemiology is the study of the cause of disease, looking at the way people may be exposed to things in the environment that may make them sick. I needed to understand what causes environmental-related diseases, so I did a postgraduate degree in environmental epidemiology and another one in contaminated land management. Together, this helped me understand exposures, health risks and ways to prevent people from become sick.

As important as my formal training was the experience that I gained working in different jobs. I worked in a poison's unit and at an action research group looking at rural health. The action research took me into communities and helped me realise that I wanted to work in activism and advocacy. This would help me make a real difference in people's lives.



Rico Euripidou.

Thank you to Rico Euripidou for being interviewed by Quest

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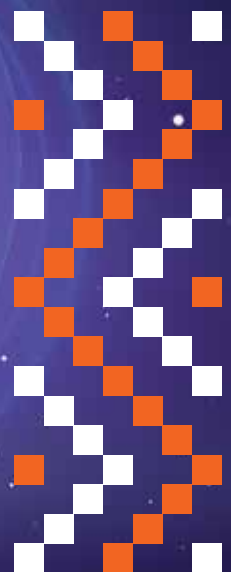
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South African National Biodiversity Institute's Succulent Poaching Working Group

A growing international demand to collect and grow rare succulents has resulted in South Africa experiencing a rapid increase in illegal succulent plant poaching. This poaching, in the Western and Northern Cape provinces, is driving restricted range endemic species to extinction.

Custodians of the region have observed that there is a notable trend in the worsening conservation statuses of plant species across several in-demand plant groups. For example, 34 species in the group *Conophytum* were uplisted to more threatened categories according to conservation assessments undertaken for South African plants. Many other such species are being targeted by collectors.

The Succulent Karoo is a national treasure

The Succulent Karoo Biome lies in the arid western parts of South Africa that receive rainfall in winter. Its uniqueness is summarised as follows:

- The Succulent Karoo is one of South Africa's three globally recognised biodiversity hotspots.
- The hotspot is the most biodiverse arid ecoregion in the world with an exceptional richness and diversity of flora, especially succulent plant species.
- Of the ~6,356 plant species described from this region, almost 40% are endemic. This means that South Africa houses (and is responsible for preserving) just under 2,500 succulent plant species (representing around 100 genera) that are found nowhere else on Earth.
- The high diversity of dwarf leaf-succulent shrubs (~1,700 species) is the biome's most distinctive character, however, the region also supports a notable diversity of bulbs, insects, reptiles, birds, small- to medium-sized mammals, as well as a host of microorganisms (such as fungi and cyanobacteria).
- The observed massive speciation has emerged in response to unique climatic conditions and high environmental heterogeneity, including the geology, topography and soils. Adding to this, many species are so specialised in their habitat requirements, as they have adapted to life within a limited range of environmental conditions and across very limited areas (<50 km²), resulting in a phenomenon known as point or local endemism.
- Only a small percentage (<10%) of the Succulent Karoo is formally conserved. The current protected area network is, unfortunately, not representative of the region's biodiversity and does not incorporate key ecological processes and evolutionary biodiversity drivers.



Figure 1. The highly poached and targeted *Conophytum* succulent plant species.

- Approximately 5% of the Succulent Karoo Biome has already been lost to anthropogenic land use, the majority to croplands. Although this leaves 95% of the area as 'natural', there is no comprehensive land degradation dataset for the biome and various studies indicate that degradation through overstocking of the natural rangelands is widespread. The soon to be released 'Red List of Ecosystems 2020/2021' includes four threatened ecosystem types in the Succulent Karoo.

- The region has, until recently, received limited conservation focus in relation to its global biodiversity value, however, the large areas of available extant (degraded and pristine) habitat, low human population densities, relatively low conservation costs in most of the region, and options for biodiversity-friendly forms of land use in many areas present many opportunities for conservation and sustainable development centred around the hotspot's remarkable biodiversity.

SANBI's role in the succulent poaching issue

Various divisions and directorates at SANBI are affected by the succulent poaching issue, as follows:

- The recent observed surge in poaching of succulent plants is affecting the operations at some of SANBI's national botanical gardens, as they struggle to process and care for the thousands of confiscated plants.
- The institute has also taken steps to improve the security of its biodiversity data, as citizen science platforms are known to have been used by poachers to locate sought-after plants.
- SANBI's Threatened Species Programme monitors the status of in situ (on-site) populations of succulent plant species and undertakes national conservation assessments of all South Africa's species. Updates of Red List assessments for key succulent species will be needed.
- SANBI also provides technical support to the Scientific Authority of South Africa, which advises government on sustainable use and trade in South Africa's wildlife.

identify and undertake key activities that will contribute to alleviating the impacts of this crisis. To date the SPWG has identified the following objectives:

1. Co-lead the development of the national response strategy with DFFE, ensuring stakeholders are adequately consulted.
2. Establish ex situ (off site) conservation collections that ensure genetically diverse repositories. This will include a *Conophytum*-specific collection at the Karoo Desert National Botanical Garden and additional seed collection for the Millennium Seed Bank.
3. Optimise the use of confiscated plant material for conservation benefit – which may include using this material as mother stock to produce seed and seedlings.
4. Explore options for reintroduction and restoration if reintroduction sites can be secured from further poaching.
5. Seek, secure and manage funding to address SANBI's ability to undertake these objectives.

The Saving Succulents Communication Team consists of (in alphabetical order): Carol Poole, Dane McDonald, Ismail Ebrahim, Ruqaya Adams, Sediqa Khatieb, Shahieda Davids, Tasneem Variawa and Zimkita Mavumengwana.

First published by the South African National Biodiversity Institute (SANBI) in the SANBI Gazette November 2021. Republished with permission.

Recently, SANBI has been involved in co-leading a working session with colleagues from the Department of Forestry, Fisheries and the Environment (DFFE), which brought various stakeholders together with the aim of developing a national response strategy.

In addition, SANBI has created an internal Succulent Poaching Working Group (SPWG), which is an inter-divisional group that aims to coordinate efforts across SANBI to

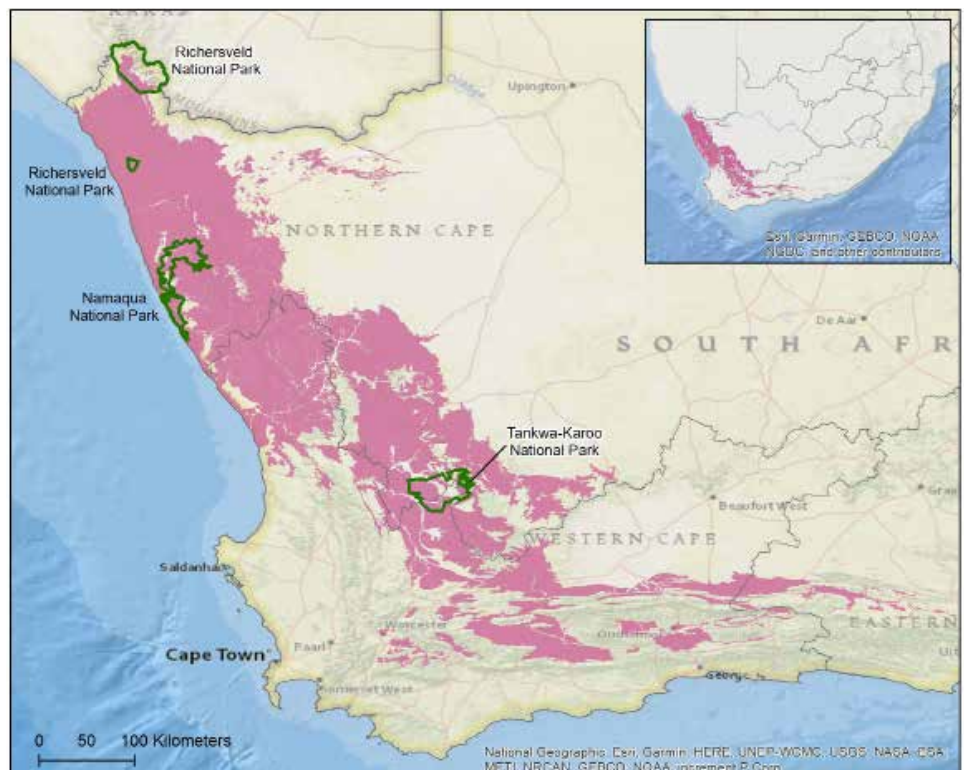


Figure 2. A map of the Succulent Karoo Biome. Map produced by Sediqa Khatieb.



Tea cups, aerial view.

Teacup artwork highlights environmental issues

What can you do over a cup of tea? Rather a number of socially significant things, such as hooking up with old friends. At the Walter Sisulu National Botanical Garden (NBG) a cup of tea became the product of innovation when more than 2,000 cups were used to create an impressive artwork in June 2021.

The South African Rooibos Council decided to pledge support to efforts to better manage the environment with a display titled 'Working towards a sustainable future'. The South African National Biodiversity Institute (SANBI) was a suitable partner as the environmental champion and Walter Sisulu NBG was the host venue.

The display was part of the annual World Environment Day celebrations that seek to highlight the importance of good environmental management for a sustainable future. The artwork installation was the product of mixed media artist Gina Waldman, who was commissioned to do the artwork using various rooibos tea blends that were carefully positioned to resemble a globe when viewed from above.

SA Rooibos director, Nicie Vorster, said the industry was renewing its focus on sustainability. Vorster also said in the statement they chose to illustrate their pledge towards social and environmental stewardship in a creative way,

because art has the ability to connect with people on emotional and subliminal levels, sometimes inspiring a heightened appreciation for nature or a re-evaluation of human progress.

"On average, about 14,000 tons of rooibos are produced every year, of which half is consumed locally, while the rest is exported to more than 30 countries across the globe. Germany, the Netherlands, Japan, UK and the US are currently the biggest importers of the tea," said Vorster. "While enormous strides have been made to make the rooibos tea chain more sustainable, we can always do more, and we will build on the foundation we have to continue working on all three dimensions of sustainability — environmental, economic and social — while also taking the Agenda 2030 Sustainability Development Goals into account."

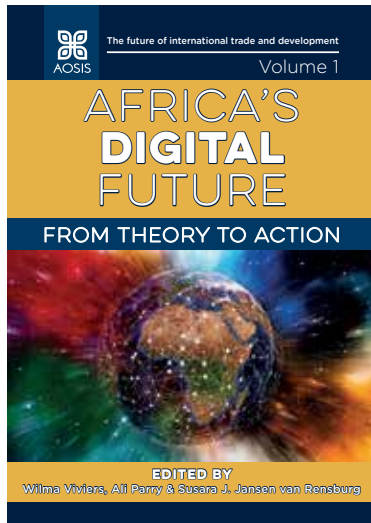
Vorster emphasised, "As our sustainability journey continues to gain momentum, we are encouraging other industries and the public to also play their part in preserving the environment and building a green economy in which all can thrive."

Written by Ronny Tshabalala. First published by the South African National Biodiversity Institute (SANBI) in the SANBI Gazette November 2021. Republished with permission.

Books

Africa's digital future: From theory to action

Edited by Prof Wilma Viviers, Ali Parry and Dr Adelia Jansen van Rensburg



The WTO Chairs Programme in the TRADE research entity at the North-West University (NWU) in South Africa is delighted to announce the publication of a new book, *Africa's digital future: From theory to action*.

In keeping with the NWU's reputation for high-quality research in diverse fields, including science and technology, international

trade, economics and law, *Africa's digital future* makes an important and timely contribution to the literature on Africa, exploring the many opportunities and challenges that the continent faces in a world characterised by accelerating technological change.

Edited by Prof Wilma Viviers, Ali Parry and Dr Adelia Jansen van Rensburg, the book has been published in an online format by AOSIS, the open-access publisher which hosts a wide range of journals and independent publications on its platform. The book is therefore freely available to anyone who wishes to read it online or download a copy. Get your copy at: <https://books.aosis.co.za/index.php/ob/catalog/book/199>

The overarching question that *Africa's digital future* addresses is whether African countries have the foresight, resources and motivation to leverage the considerable power of digital technologies to transform their economies in sustainable and inclusive ways.

The book comprises 10 chapters which examine a wide range of topics that are central to Africa's growth and development prospects – industrialisation, global and regional value chains, transport and logistics, trade facilitation, labour-market dynamics, employment, education, policies and regulations, and more – all through a digital lens, with digital trade forming the backdrop to several of the chapters.

Other trade experts who contributed chapters to the book are Prof Peet Strydom, Dr Marie-Luce Kühn, Dr Emmanuel

Orkoh, Prof Sonja Grater, Prof Alwyn Hoffman and Biandri Joubert – all of whom are members of the extended research network of the NWU, the WTO Chairs Programme and the TRADE research entity.

The steady encroachment of automation, artificial intelligence (AI), cloud computing and other digital technologies into people's lives has attracted much research interest around the world. But few publications (until now) have delved deeply and thoroughly into the implications of digitalisation for Africa specifically and what countries on the continent need to do to chart a steady course into the future.

Written in an engaging style which will appeal to a wide audience, *Africa's digital future* combines academic rigour with reflective policy-related commentary, emphasising the need for Africa to realistically consider its future while not forgetting its past. The word 'action' in the title is intended to convey a sense of urgency and to emphasise that Africa needs to own its future if it is to benefit from it.

For more information about the publication, contact Prof Wilma Viviers on wilma.viviers@nwu.ac.za.

VISION NEVER DIES

By Refilwe Phaswana-Mafuya



Refilwe Phaswana-Mafuya, an award-winning scientist and fighter of pandemics, shares her interesting career journey from humble, difficult beginnings to the success that she is today. She shares the valuable insights and wisdom she gained along the way. Divided into learning curves, each curve is designed to help learners navigate their way through their education,

studies and career, and to help learners navigate their way through their education, studies and career, and to help keep them motivated and fixed on the goal ahead, even when facing obstacles. Refilwe has become a mentor to other visionary young women, and each of their stories are included in the book as well. Together, the career journeys in the book provide techniques, tools, and testimonials to inspire and empower EVERYONE in their own careers and lives.

Quest

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Quest is full-colour and published on a quarterly basis. Each issue aims to have a theme. For example, an issue may be aligned with the United Nations General Assembly themes: the International Year of Artisanal Fisheries and Aquaculture (IYAFA 2022) and the International Year of Glass (IYOG 2022).

An issue of Quest typically comprises five themed articles (1500 words), five feature articles (1300 words), four news pieces (500 words), and two to three book reviews (400 words). Images, graphics, infographics, etc. are encouraged.

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IN MEMORIAM

A tribute to our dear colleague, the late

TSEPO MAJAKE

25 May 1970 – 20 June 2022

During the final stages of editing this edition of Quest, ASSAf lost one of its most beloved colleagues and one of the most ardent campfighters for Quest's mission to spread science to South Africa's youth. Here, we honour his love for, and contribution to the magazine – and the memories he leaves us with.

It was with shock and extreme sadness that we learned of the passing of Tsepo Majake, on the 20th of June 2022. How does one express the amazing essence and spirit of someone like Tsepo, the Education Liaison Officer at ASSAf from 1 March 2015 to 20 June 2022. His selfless generosity, integrity and uncompromising belief in all that is good, his unwavering commitment to science awareness amongst the youth of South Africa and the *Quest* magazine in particular, are unparalleled. Words cannot pay tribute or truly capture the sense of loss of such a genuinely warm, passionate, intellectual and wonderful individual.

The loss is there, tangible and real within everyone, but Tsepo exemplified life, love, laughter and an irrepressible belief and faith in seeing the best in everything.

We wish to honour him by expressing not only our sorrow for this profound loss, but also by remembering Tsepo as an amazing person who played a unique and special role in the lives of all he came into contact with. Our lives will be empty in the areas that he had brightened for us.

Soon after Tsepo joined ASSAf, his presence could be felt. His passion for science engagement and communication was tangible. He loved interacting with others and inspiring young people to choose science as a career. He was charismatic and friendly and he had the ability to engage with all he came into contact with. These exceptional and rare qualities were a great asset to the Scholarly Publishing team and *Quest's* outreach programme in particular. He was the support anchor for the *Quest* Science for South Africa team.

Tsepo will be remembered for all his National Science Week activities, more especially the highly successful Graaff-Reinet outreach in 2018 and for the pivotal role he played in the Khayelitsha Outreach funded by the Carnegie

Foundation in 2016. Tsepo was a man of stature, with a commanding yet warm voice, who spoke with knowledge, confidence and authority when he interacted with large groups of learners. During the COVID pandemic he arranged and facilitated many webinars on a vast variety of interesting topics. His ability to probe questions got the speakers talking. Tsepo was often included in interview panels at ASSAf as he had the gift of putting those being interviewed at ease and he was particularly good at gauging the employability of candidates and whether they would be a good "fit" for ASSAf.

Tsepo had a big heart and was a loyal colleague and a special friend to many at ASSAf and in the Scholarly Publishing Unit and to the *Quest* editorial board, in particular. We were privileged to have had an opportunity to share seven years of his journey at ASSAf. We celebrate his life. Here was a life that demanded notice ... a life that exemplified professionalism and passion for his work ... a life that inspired others ... a life that burned so that others' paths were lit.

He generously gave of his knowledge, his wisdom, his expertise and his skills. As such his intelligence, insightfulness, depth and understanding of people and the dynamics between people made him the ideal advisor and problem-solver in our organisation.

He was ever the gentleman and was known and commended for his dress sense when it came to the suits, ties and waistcoats he wore to formal meetings. He will be fondly remembered for his infectious laughter and warm smile, and more so for his delightful sense of humour. This following quote encapsulates Tsepo's life: "It is not the years in a life that count; it is the life in the years" (Abraham Lincoln, former American President).

Our hearts and prayers are with his family at this most difficult time.

A video tribute compiled by ASSAf in memory of Tsepo Majake can be viewed at: https://youtu.be/nR1Wmj_FHNY



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