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Scientific
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Scientific African Magazine

Scientific African Magazine documents science and technology developments in Africa and from Africans for the general public. We review innovations that matter. We ask the hard questions. We highlight best practices. The Magazine is published by the Next Einstein Forum (NEF).
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EDITORIAL

Editor In Chief
Nathalie Munyampenda

Lead Editor
Linda Nordling

Journal Editor
Benji Gyampoh

Publisher
Next Einstien Forum [an AMS Initiave]

Layout Design
Ibrahim A. Hassan [iBU]

Address
Next Einstien Forum
KG 590 St, Kacyiru, Gasabo
Kigali, Rwanda

Print Production
Next Einstien Forum
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CONTENTS

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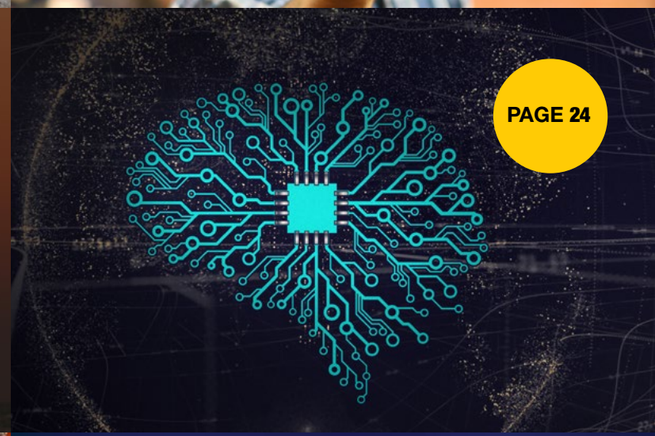

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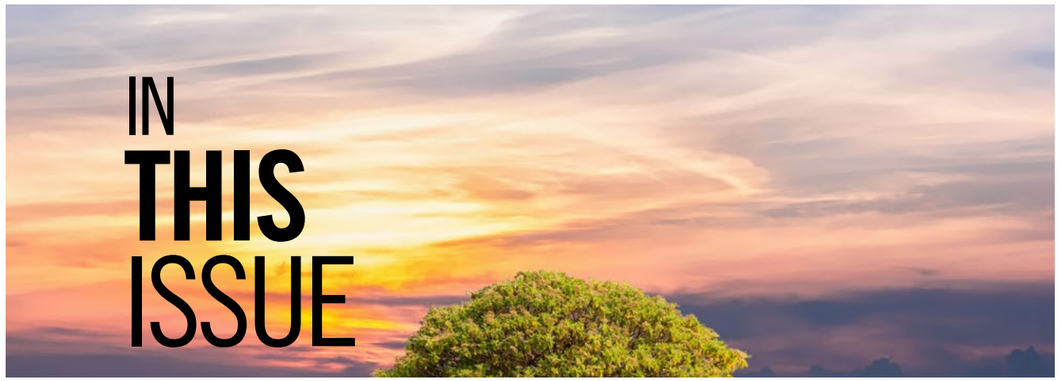


IN THIS ISSUE

Scientists predict that African countries

will be among the worst affected by human-induced climate change. But what exactly is going to happen? And what can we do to prepare for the flooding, droughts, biodiversity loss, and human migration coming our way? These urgent questions need evidence-based answers.

In this issue of *Scientific African Magazine*, two of the feature stories explore how climate change will affect our food supply: Warmer and wetter weather could fuel the production of poisons by moulds on crops such as maize and wheat, cancelling out efforts to battle this scourge *(Fighting the fungus, page 26)*. And across Africa, changing weather patterns combined with deforestation could deplete wild-growing plants that many Africans depend on for food and medicine *(Saving Africa's wild larder, page 22)*.

As the world battles to prepare for climate change, there is also a real and worrying risk that African countries will be left out of global decision-making about the planet's future. The feature *Dialing down the sun (page 20)* showcases an African first, three projects that will explore how solar geoengineering—as-yet theoretical programmes to deliberately deflect some of the sun's rays from reaching the Earth's surface to prevent warming—could affect three African regions.

Many of the stories in this magazine are linked to papers published in *Scientific African* journal earlier this year. They illustrate how new African research has a vital role to play in addressing the myriad challenges facing the continent.

Another milestone in this issue is the diversity of its contributors. Ten African or Africa-based journalists and scientists hailing from eight different African countries, the majority of them women, have written news, features and opinion pieces for this magazine. This means that what you are reading is not just a collection of cool African science stories penned by people from elsewhere. It's a science magazine written by Africans, for Africa and the world.

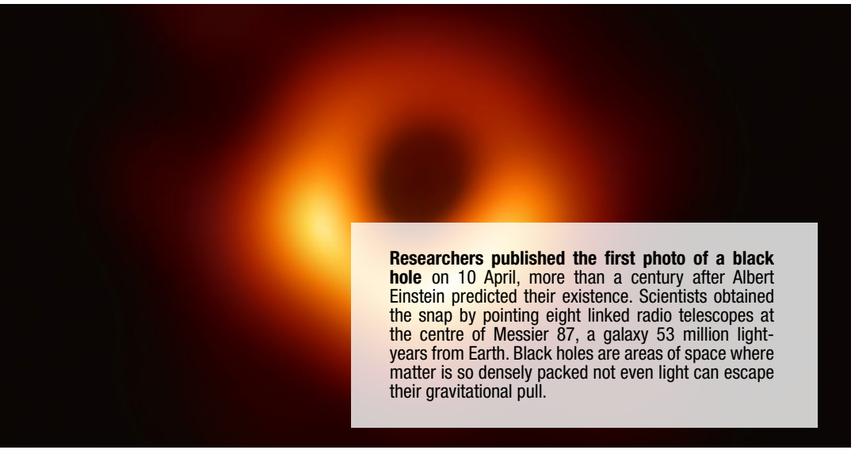
As the world battles to prepare for climate change, there is also a real and worrying risk that African countries will be left out of global decision-making about the planet's future.

If you think we should be covering an important, science and innovation driven, Africa relevant story, write to us at: magazine@nef.org

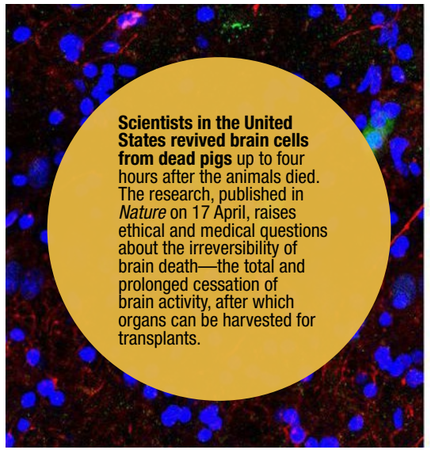
Nathalie Munyampenda and Linda Nordling

In Brief

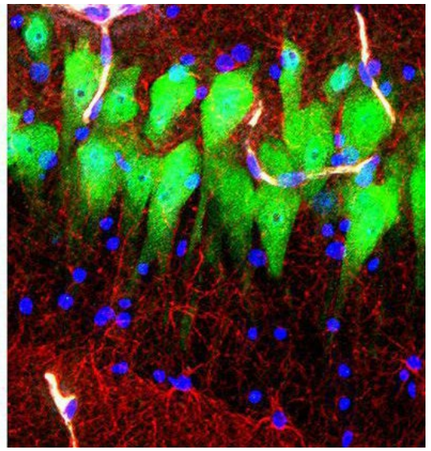
Top science news from around the world

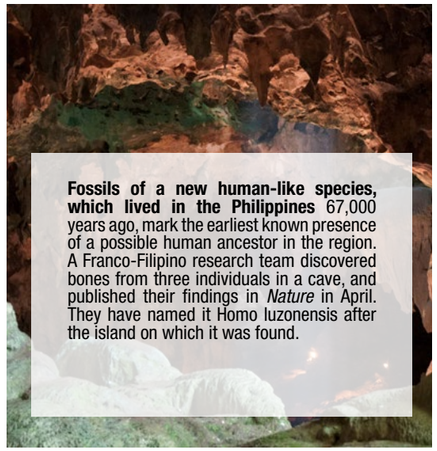


Researchers published the first photo of a black hole on 10 April, more than a century after Albert Einstein predicted their existence. Scientists obtained the snap by pointing eight linked radio telescopes at the centre of Messier 87, a galaxy 53 million light-years from Earth. Black holes are areas of space where matter is so densely packed not even light can escape their gravitational pull.

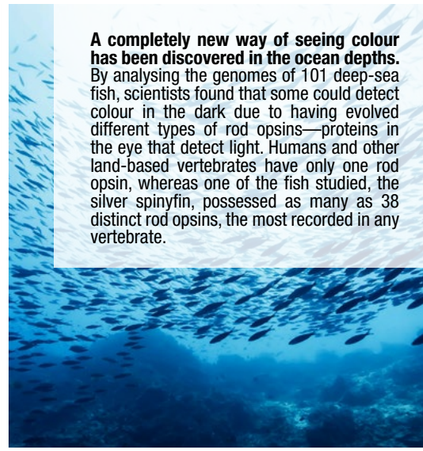


Scientists in the United States revived brain cells from dead pigs up to four hours after the animals died. The research, published in *Nature* on 17 April, raises ethical and medical questions about the irreversibility of brain death—the total and prolonged cessation of brain activity, after which organs can be harvested for transplants.





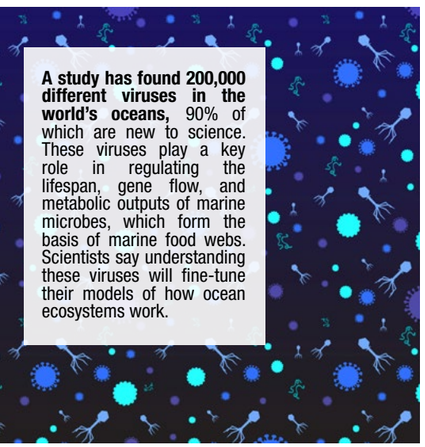
Fossils of a new human-like species, which lived in the Philippines 67,000 years ago, mark the earliest known presence of a possible human ancestor in the region. A Franco-Filipino research team discovered bones from three individuals in a cave, and published their findings in *Nature* in April. They have named it Homo luzonensis after the island on which it was found.



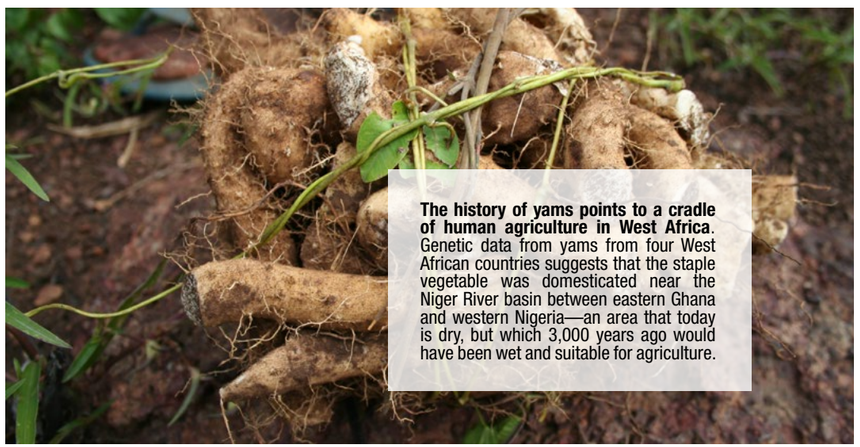
A completely new way of seeing colour has been discovered in the ocean depths. By analysing the genomes of 101 deep-sea fish, scientists found that some could detect colour in the dark due to having evolved different types of rod opsins—proteins in the eye that detect light. Humans and other land-based vertebrates have only one rod opsin, whereas one of the fish studied, the silver spinyfin, possessed as many as 38 distinct rod opsins, the most recorded in any vertebrate.

A million species worldwide could go extinct, some within decades, as a result of human-caused environmental degradation. This is the sobering message of the sixth assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. The 6 May report warns that more than 40% of amphibians, almost 33% of reef-forming corals, and more than a third of all marine mammals are threatened.

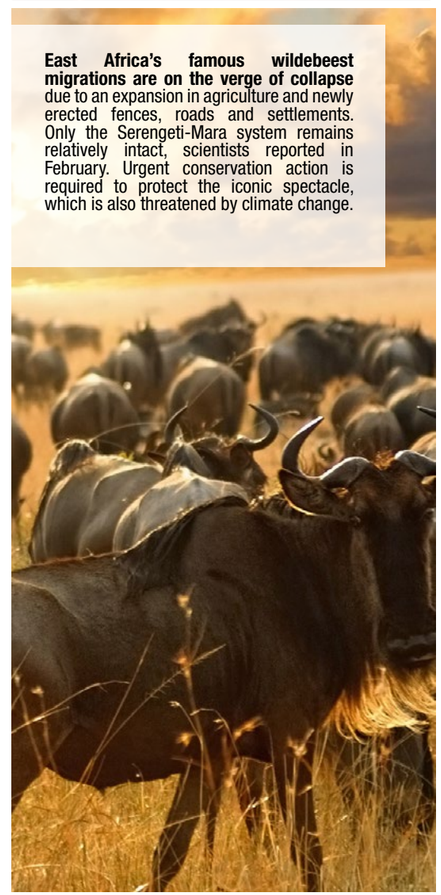
The world's first proven malaria vaccine is being rolled out in three African countries. The large-scale pilot started in Malawi on 23 April, with Ghana and Kenya planning to join the project. The RTS,S vaccine is given to children under two and the pilot could reach up to one million African children by 2023. But the vaccine is only partially effective. In clinical trials, it protected just four in ten children.



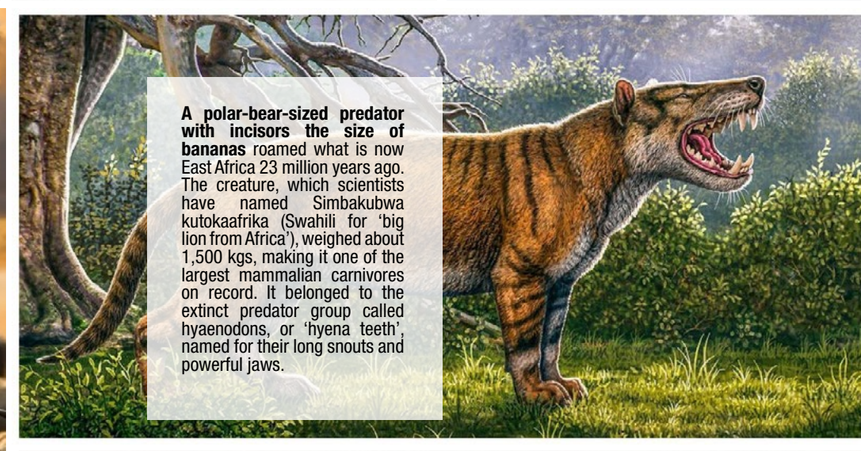
A study has found 200,000 different viruses in the world's oceans, 90% of which are new to science. These viruses play a key role in regulating the lifespan, gene flow, and metabolic outputs of marine microbes, which form the basis of marine food webs. Scientists say understanding these viruses will fine-tune their models of how ocean ecosystems work.



The history of yams points to a cradle of human agriculture in West Africa. Genetic data from yams from four West African countries suggests that the staple vegetable was domesticated near the Niger River basin between eastern Ghana and western Nigeria—an area that today is dry, but which 3,000 years ago would have been wet and suitable for agriculture.



East Africa's famous wildebeest migrations are on the verge of collapse due to an expansion in agriculture and newly erected fences, roads and settlements. Only the Serengeti-Mara system remains relatively intact, scientists reported in February. Urgent conservation action is required to protect the iconic spectacle, which is also threatened by climate change.



A polar-bear-sized predator with incisors the size of bananas roamed what is now East Africa 23 million years ago. The creature, which scientists have named Simbakubwa kutokaafrika (Swahili for 'big lion from Africa'), weighed about 1,500 kgs, making it one of the largest mammalian carnivores on record. It belonged to the extinct predator group called hyaenodons, or 'hyena teeth', named for their long snouts and powerful jaws.

Ebola has now killed more than 1,000 people in the Democratic Republic of the Congo. The World Health Organization says the spread of the virus could accelerate after militias attacked several treatment centres. The location of the outbreak, in the conflict-ridden eastern DRC, is hampering efforts to contain and treat the deadly disease. A local epidemiologist, Richard Mouzoko, was killed in one of the attacks.

Yam genetics unveil cradle of agriculture in Africa

Photo Credit: Google Stock

By Sandrine Ceurstemont
A freelance journalist based in Morocco.

African yams were domesticated from a forest species and cultivated for the first time in an area around the Niger River. The findings, published in the journal Science in May, provide new evidence for a cradle of agriculture in sub-Saharan Africa.

Nora Scarcelli from the French Research Institute for Development in Montpellier, France and her international team investigated the genes of yams growing in Ghana, Benin, Nigeria, and Cameroon. These countries are part of Africa's 'yam belt' where 97% of the continent's yams are produced.

The study is the first to include yams from different countries, Scarcelli told Scientific African Magazine. She and her colleagues sequenced the entire genome of 167 yam plants of the main cultivated species, Dioscorea rotundata, and two of its wild relatives, D. abyssinica and D. praehensilis. Their full set of genes allowed the team to use sophisticated models to uncover detailed information about African yams, such as their geographical origin and evolution.

The researchers investigated whether one of the wild yam species or a hybrid was the ancestor of the cultivated variety. It has often been suggested that sub-Saharan plants were first domesticated in savannahs since that's where they are mostly cultivated today.

"In Ghana, for example, you realise that most of the cultivation is within the forest-savannah transition and the beginning of the savannah," says Emmanuel Otoo, a member of the team who is based at Ghana's CSIR-Crops Research Institute. So, the savannah species D. abyssinica might seem a more likely candidate for early domestication than D. praehensilis, which is found in forests, he says.

But the team's models revealed that the forest species D. praehensilis is the most likely ancestor of cultivated African yams and that domestication started in the Niger River basin between eastern Ghana and western Nigeria. That was a surprise to Scarcelli, who was expecting yams to originate further south. The Niger basin is dry and the forest species no longer grows there. But the climate was different in the past. "If you look back 3,000 years ago, this place was wild, wet, and there was forest," she says.

The study also pinpointed changes in genes as yams were domesticated, which could be of interest to breeders. The team identified genes linked to tuber size, starch content, and resistance to light. Rajeev K Varshney, a molecular geneticist at the International Crops Research Institute for the Semi-Arid Tropics in Hyderabad, India, who was not part of the research team, thinks this new knowledge is important and could help create better yam varieties in the future.

But the insights from Scarcelli's team could also put Africa on the map as a cradle of domestication, pitting it against the Fertile Crescent in the Middle East which is usually considered to be the birthplace of agriculture. "With similar work in African rice, pearl millet, and sorghum, it may now be possible to get a regional picture of how crops were domesticated on this continent," says Michael Purugganan, a biologist at New York University in the United States who was not involved in the research.

Scarcelli and her colleagues now plan to examine how yam cultivation spread from its birthplace to other parts of Africa as well as to South America and the Caribbean. They also want to investigate the impact of climate change on the crop. "[What] we will try to see is if yam is in danger or not," says Scarcelli. "We will try to predict how it will be possible to cultivate yam and where it will be possible to cultivate it."

Journal reference: Science, DOI: 10.1126/sciadv.aaw1947

Photo Credit: Google Stock

The health benefits of waakye, Ghana's secret superfood

By Jessica Ahedor
A freelance journalist based in Accra, Ghana

Ghanaians are crazy about waakye—a local dish prepared by cooking rice and beans with red sorghum leaves. The leaves add flavour and give waakye (pronounced waa-che) its distinctive reddish-brown colour. The leaves are also rich in antioxidants, which in turn can be good for human health.

But the health benefits of eating waakye are poorly understood. Antioxidants can protect cells in the body from damage and are thought to help fight a range of illnesses like heart disease, cancer, and diabetes. However, antioxidant levels in food and their effects can be affected by cooking methods, and waakye is no exception.

In order to examine whether the antioxidants in the sorghum leaves survive cooking waakye, Edward Essuman, a food scientist at the University of Health and Allied Sciences in Ho, Ghana, tested waakye made using four different cooking methods. One sample was prepared without any red sorghum leaves at all. One was prepared with red sorghum leaves that had been soaked in water for 12 hours; in another, the red sorghum leaves were soaked overnight in water containing saltpetre, a chemical used in curing meat, used here to help leach the leaves of their colour and nutrients. In the final sample, he added fresh sorghum leaves halfway through cooking.

The findings of their research were published in Scientific African in March 2019. Essuman and his colleagues found that waakye prepared with sorghum leaves had higher antioxidant levels than the sample prepared without—showing that the sorghum leaves did indeed confer health benefits to waakye. The antioxidant levels were the highest in the waakye prepared with saltpetre, Essuman said. "The saltpetre helps retain all the nutrients in the food as compared to cooking without it." But using too much saltpetre in waakye preparation might cause indigestion and should therefore be used sparingly, he and his colleagues warn.

To many waakye lovers in Ghana, the health benefits of the staple come as a surprise. Kafui Adzah is the owner of Waakye on Wheels—an online on-demand waakye delivery service that delivers in Greater Accra. She has sold waakye since 2014, and says that the timing of her delivery service and the consistency of her product, coupled with its great taste, give her the edge. But she says that while she knew that the sorghum leaves added the colour, she didn't know they had nutritional value. "Waakye is waakye, all I did was to give it an appealing look and deliver on time on orders. I never heard of any benefits about the leaves," she says.

According to Essuman, waakye could be a cheap source of not only antioxidants, but also essential fatty acids and fibre. And the findings could pave the way for other nutritional applications of sorghum leaves, says Reginald Annan, a nutritionist at Kwame Nkrumah University of Science and Technology in Kumasi, Ghana, who was not part of the study. Apart from their use as livestock feed, there is currently no other use for red sorghum leaves in food preparation, he says. "It is time for us to research alternative uses of the leaves so that those who don't patronise waakye can also have access to the nutrients."

New treatment offers hope for Kala-Azar victims who also have HIV

By Maina Waruru
A freelance journalist based in Nairobi, Kenya

A new treatment for patients suffering from both HIV and the deadly parasite-borne disease Kala-azar has shown impressive cure rates, raising hopes for thousands of patients worldwide.

Kala-azar, also known as visceral leishmaniasis, is caused by parasites that infect humans through sandfly bites. The parasites attack the spleen, liver and bone marrow causing fever, weight-loss and swelling, and can be fatal if left untreated.

In otherwise healthy individuals, Kala-azar can be successfully treated with Amphotericin B, a primarily antifungal drug which kills the Leishmania parasites quickly. But in HIV infected individuals this treatment often fails, and chances of relapse are high. The two diseases make each other worse: HIV weakens the immune system making carriers susceptible to Kala-azar, while Kala-azar speeds up HIV replication and progression to Aids.

"This is because the HIV virus and the Leishmania parasite target the same cell, the macrophage, which is one of the main actors in the response of the host to infections, impairing the immune system," says Jorge Alvar, senior advisor on leishmaniasis at the Drugs for Neglected Diseases Initiative based in Geneva, Switzerland.

Alvar is one of the lead scientists on an Ethiopian study that investigated a combination therapy for HIV infected patients with Kala-azar. The research team also included scientists based in Ethiopia and Kenya. The study's results were published in PLOS Neglected Tropical Diseases in January this year, reporting cure rates of between 67% and 88% in co-infected individuals when using Amphotericin B in combination with miltefosine, a broad-spectrum antimicrobial drug. Amphotericin B on its own only cures at most 59% of co-infected patients.

The two drugs work together to beat their common enemy, Séverine Blesson a study co-author from DNDi, told Scientific African Magazine. Amphotericin B is fast-acting, she said, while miltefosine has a long half-life which means it tackles any surviving parasites.

The insight has the potential to help many people. Up to 90,000 cases of Kala-azar are recorded across Asia, Africa, and South America every year, killing up to a third of sufferers. Co-infection between HIV and Kala-azar has been reported in 35 countries, and HIV positive individuals make up between 1% and 10% of all Kala-azar sufferers, although in northwest Ethiopia it's almost 40%.

Following the publication of the study results in January, the Ethiopian government has endorsed the 'compassionate' use of the combination therapy, meaning it can be used for treatment despite not being licensed yet for such use. The procedure to change national guidelines are underway in Ethiopia, Alvar says.

The World Health Organization is also producing new recommendations for how to treat Kala-azar and HIV coinfection based on the Ethiopian study and another, which produced similar results, in India. But this process could take more than a year. Jose Antonio Ruiz Postigo, who heads up the WHO's global leishmaniasis control programme, says this is standard procedure for new treatments.

However, it could prove tricky to ensure all sufferers can access the combination therapy, as miltefosine is expensive and not readily available in many regions. In addition, the drug is teratogenic, which means it can harm developing fetuses in the womb. This means pregnant women must not take the treatment, and patients should avoid falling pregnant while taking it, Ruiz Postigo says.

Funding could be another stumbling block. No donor has yet committed to finance the procurement of miltefosine according to Abate Beshah from the WHO Africa focal point for leishmaniasis, who cautions that it is too early to celebrate just yet.

Photo Credit: EC/ECHO/Martin Karimi

Photo Credit: Google Stock

Genetics help solve puzzle of how goats spread through Africa

Photo Credit: Google Stock

By Sarah Wild
A freelance journalist based in Johannesburg, South Africa

Eleven thousand years ago in the Middle East, goats became one of the first herbivores that humans domesticated. Since then, the horned livestock have spread across the world. But how domestic goats (Capra hircus) found their way to all corners of the African continent—where they are now an important source of meat and milk—remains poorly understood.

Archaeological data suggests that goats entered Africa from the Middle East 7,000 years ago with humans. Little is known about how they continued to disperse after that, and whether there were multiple waves of migration. But by analysing genetic data of modern goats scientists can retrace their journey.

A study published in *Plos* ONE in April, analysed the genetic footprints of Cameroon's approximately 6.2 million goats, finding that they first travelled to the West African country via the Nile Delta. They also identified a second wave of genetic mixing with North African goats as humans migrated from what is now Morocco about 1,500 years ago.

Very little is currently known about the genetic composition of African countries' livestock populations. This hinders the ability of farmers and researchers to identify adaptive traits and pockets of low genetic diversity. The international team took a two-pronged approach, investigating the mitochondrial DNA (which traces the maternal line) and autosomal markers (which are genes that point to ancestry).

Goats have six distinct maternal DNA lineages or haplogroups (which are populations descended from a common ancestor), three of which are found on the African continent. Haplogroup A, the dominant one, has been identified throughout Africa, while Haplogroup B goats are found in South Africa and Namibia. Haplogroup G goats live in Egypt, Kenya, Somalia, Sudan, and Ethiopia.

The researchers extracted DNA from four indigenous goat populations in Cameroon, namely the Central Highland, North-west Highland, Forest, and Djallonke groups. They applied mitochondrial DNA analysis to 93 goats (from the Djallonke and North-west Highland populations), and autosomal tests to 324 goats from all four populations and compared them with genetic data from goats in Ethiopia, Egypt, Morocco, Iran, and China.

They identified 83 haplotype markers, all of which belonged to haplogroup A. An analysis of mitochondrial DNA showed that the goats' genes flowed from the North-east of the continent, following the Nile Delta to Cameroon, says Getinet Tarekegn, a geneticist specialising in livestock and lead author on the paper. "This is strongly supported by social anthropology and African people genetic studies."

However, more data is needed to say definitively that this is how goats came to Cameroon, notes Tarekegn, who is affiliated to Bahir Dar University in Ethiopia and the Swedish University of Agricultural Sciences in Uppsala.

He says scientists need to compare ancient and modern DNA, including samples from north and east African countries, and contrast this with historical evidence of human migration. Studying human movements and environmental pressures like desertification could also provide insight into livestock dispersal, he says.

Tarekegn says knowing more about African goat genetics can help keep track of genetic diversity on the continent, which could aid conservation and breeding efforts. Future studies could look at the unique genetic potential of each goat population and its correlation with the ecological environment, he says. "That is why we are working on those activities, not only for Cameroon goats but also goat populations found in other African countries and beyond," he says.

Hannelize Swart, an animal geneticist at the Agricultural Research Council in South Africa, welcomed the "thorough" research, although she noted that it may be too complicated to be of help to farmers in the livestock sector. "The fact that there is collaboration between laboratories from different countries makes it valuable for local researchers to follow their example or to get involved in similar research and collaborate with the authors," she says.

In Kenya, tomato farming is a male affair

By Maina Waruru
A freelance journalist based in Nairobi, Kenya

Smallholder tomato farming in Kenya remains dominated by older men despite efforts by the government NGOs to encourage women and youth into agriculture and to foster equality in land ownership, scientists have found.

In Kenya, seven out of ten tomato growers are male according to a study conducted by a group of Nairobi-based scientists and published in Scientific African in March. Of these male farmers, 73% are between the ages of 36 and 60.

It suggests that women and youth benefit less than they might from Kenya's booming tomato growing industry, the researchers say in their paper. "The findings of this study underscore the need to increase women and youth participation in tomato production."

Kenya is one of sub-Saharan Africa's top tomato producers. It grows more than 400,000 tonnes of the fruit every year, which corresponds to 7% of its total horticultural production. Tomatoes are also an important source of income for smallholder farmers, who produce 80% of the country's total rop.

The research team, led by agricultural entomologist Willis Ochilo from the Centre for Agriculture and Biosciences International, surveyed close to 5,000 tomato farmers for their study. They reached that number by using intermediary 'plant doctors' to help them collect data. Plant doctors are extension officers who help farmers diagnose diseased plants and offer advice on treatment.

The plant doctors work out of 'clinics'—tents erected in market centres—spread over 121 locations in 18 different agro-ecological zones in Kenya. Ochilo and his colleagues used the plant doctors to survey the farmers who visited them over a four-year period running from June 2013 until May 2017.

It's a clever way of sampling large numbers of smallholder farmers, Ochilo says. "Through the plant clinics, one is assured of data year-round," he told Scientific African Magazine. "Also, the data collected is rich, capturing information about the farmer, the crop, plant health, and prescribed interventions."

Ochilo says the observation that more men are involved in tomato production than women agrees with findings from other studies on African tomato farming. In Ghana, a 2009 study found that 60% of the tomato farmers in the north of that country were men.

He says the gender disparity could stem from the fact that tomato cultivation is both capital- and labour-intensive, aspects that predispose it to male farmers. Tomato growing is also considered risky, he says, and women tend to be risk averse. The study found that women's tomato plots were smaller—0.24 acres on average—compared to men's 0.32 acres.

But Joel Ochieng, an agricultural biotechnologist based at the University of Nairobi, questions whether the data collection method might have skewed the data. While he agrees there are constraints facing women farmers, he believes male farmers would be more likely to visit the plant doctors. "More men would turn out since, as household heads, they have more freedom to move than women, who would perhaps need permission from the men to visit the market," he argues. The sampling technique could also have favoured the more enlightened, modern farmers, he says, adding that on-farm surveys could have yielded different results.

But Ochilo doubts the sampling technique produced the gender disparity in the survey. Indeed, he says, the data from the plant clinics showed that there are other crops that are more commonly grown by women farmers. "A look through the entire data set indicates that there are certain crops that are mostly associated with men, and others mostly associated with women, such as beans," he says.

Photo Credit: V.Atakos (CCAFS)

Getting watermelons to market in Benin

Watermelons are a popular fruit in Benin. But their profitability for market traders—95% of whom are women—is limited as a result of the country's poor rural road network, a lack of storage facilities to stop melons from rotting, and the difficulty for traders to balance customer demand with supply. Sylvain Kpenavoun Chogou, an agronomist at the country's University of Abomey-Calavi, surveyed 195 registered Beninese watermelon traders, and the results were published in the March 2019 issue of *Scientific African*. By asking traders about their monthly revenue, Chogou and his colleagues found that only wholesalers were able to earn a living wage from watermelon sales. Wholesalers earned on average seven times more every month than small-scale traders (about US$255 vs US$34). Even though small-scale traders could ask a higher price than wholesalers, transaction costs—such as transport costs—ate up a significant portion of their profits. Mobile telephone could potentially help traders plan ahead, but although 96% of traders said they had a mobile phone, fewer than one in five reported using it to access market information. Chogou and his colleagues recommended that the government should improve rural roads to help small-scale watermelon traders in Benin make a better living. This would not only help watermelon traders, but all people in Benin who earned their income growing and trading food, Chogou told *Scientific African Magazine*.


Photo Credit: Google Stock

Chogou, S.K., et al. Market structure and performance of watermelon (Citrullus lanatus) in Benin.

https://www.sciencedirect.com/science/article/pii/S2468227618302448#!

Options for keeping the lights on in Ghana

The thunk-thunk-thunk of generators is a common background noise in cities and villages where electrical power supplies are erratic. In Ghana, the government is investing in power generation capacity. But is it investing its money in the right technology? For a paper in *Scientific African* published in March 2019, four scientists from the country tested 11 power plant designs currently being considered or built in Ghana to see which best suit the country's needs. They were analysed in terms of fuel type, cost, and carbon dioxide emissions. None of the options used renewable energy sources (such as wind and solar power) as these technologies are yet to be integrated into power generation in Ghana, lead author Nana Asiedu from the Kwame Nkrumah University of Science and Technology in Kumasi told *Scientific African Magazine*. Three plant designs were found to be suitable: the SGT-400 gas/oil design is best for peak production, the Orenda OGT25000 gas/oil design for mid-load generation, while the 'coal supercritical technology' option should be used to supply baseload power. Other designs were found to be uneconomical. Unfortunately, Asiedu said he has yet to present the findings to the people in charge of power plant procurement in his country.

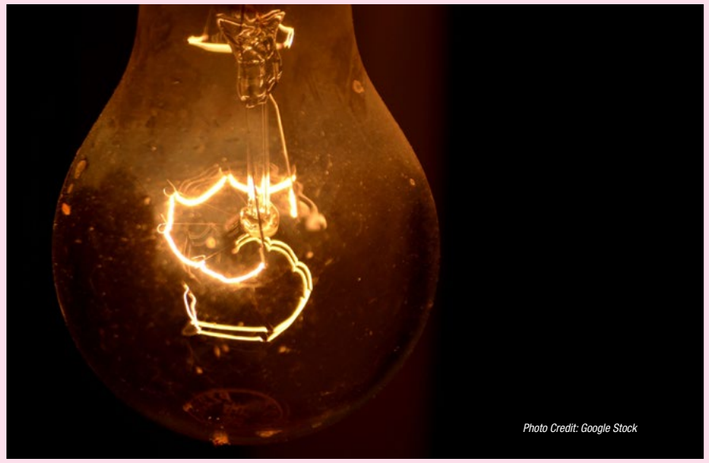


Photo Credit: Google Stock

Asiedu, N. et al. Energy economics and optimal generation mix of selected power plants technologies in Ghana

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Old cooking solutions could bring new benefits in Ethiopia

Cooking on open fires can waste fuel and produce smoke dangerous to human health—especially if the stove is located indoors. So, in the 1980s, Ethiopia rolled out two improved cooking stove designs: the Mirt made of cement and the Gonzie that could be made of local clays. Both offered similar benefits, requiring less fuel and producing less smoke than traditional designs. However, their uptake was limited. Now, a group of Ethiopian scientists has worked out why. By surveying rural associations in southern Ethiopia, they worked out that the Mirt stove was too expensive, that there wasn't enough training for users, and that the cooking plate was the wrong size. The Gonzie stove, by contrast, could be made more cheaply, but it wasn't marketed effectively. In their paper published in *Scientific African* in March 2019, the scientists suggest that pottery workers should be trained to make Gonzie stoves, which reduce wood consumption by up to 50% and emissions by up to 75%. This could improve health and curb deforestation, while still cooking traditional injera flatbreads to perfection.


Photo Credit: Google Stock

Kedir, M. F. et al. Problems of Mirt, and potentials of improved Gonzie and traditional open cook stoves in biomass consumption and end use emission in rural wooden houses of southern Ethiopia.

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Dialing down the sun

Spraying reflective chemicals into Earth's atmosphere could be an effective, if controversial, way to halt global warming. But few African scientists have studied how this technology could affect the continent—until now, Esther Nakkazi reports.

Imagine it's the year 2039. For nearly a decade, governments have been spraying reflective aerosols into the Earth's atmosphere in a desperate attempt to stave off catastrophic climate change. The reflective aerosols mean a greater proportion of the Sun's rays bounce off the atmosphere into space. It keeps the planet from overheating, but it also creates fresh worries.

In this future, dialing down the sun a notch has helped many countries around the world. With only minimal sea-level rise, cities like New York in the United States, Guangzhou in China, and Mumbai in India have been able to remain hubs of commerce and innovation. Farmers have changed what they plant, and when, in accordance with sophisticated computer models that told them how the interventions would affect weather in their location.

But in parts of Africa, crops are failing. The rains that the models said would come have not. The predictions here were wrong. Now millions of people face food shortages, and scores of farmers have gone bankrupt.

Geoengineering is the deliberate large-scale intervention in the Earth's natural systems to counteract climate change. Proposed geoengineering techniques can be grouped into two categories. Solar geoengineering reflects a small proportion of the Sun's energy back into space, counteracting temperature rise. This could be done by increasing the reflectiveness of clouds or land surfaces, blocking sunlight in space using giant reflectors, or introducing light-reflecting particles into the upper atmosphere. Carbon geoengineering involves removing greenhouse gases like carbon dioxide from the atmosphere. Proposed techniques include mass-planting trees and fertilising the ocean to bind more CO2, charring biomass and burying it to lock the carbon in the soil, or building large machines that can remove CO2 directly from air and store it elsewhere. Source: University of Oxford

Photo Credit: Google Stock

> Africa can and should have a seat at the table where these issues are being discussed."

This may sound like science fiction, but as the spectre of climate change looms ever closer, the idea of engineering our planet to stave off the worst-case warming scenarios is gaining traction. There are many suggestions for how to do this (See box), one of which—solar radiation management or SRM for short—is illustrated in this hypothetical future.

So far, most of these technologies have not made it out of the lab. Even so, there are growing concerns that the technologies could have unintended, and irreversible, consequences. And while some countries might embark on geoengineering projects to protect local interests, the results are likely to be global.

Little research has been done on how SRM might affect developing countries. In Africa, there's been hardly any work on it, which is why in 2012 a meeting in Senegal suggested that a fund be created to support African researchers modelling the impact of SRM. In December last year, the first eight research projects funded through the Developing Country Impacts Modelling Analysis for SRM (DECIMALS) fund were announced—and three of them will be carried out in Africa.

These are the first SRM research projects in their respective countries, and many are the first in their regions. "The projects therefore represent a big first step in building southern capacity to evaluate SRM," says Andy Parker, the United Kingdom-based project director of the SRM Governance Initiative which manages the DECIMALS programme in collaboration with The World Academy of Sciences in Trieste, Italy.

None of the projects will release anything into the atmosphere. They will simply use software to model what might happen if that were done, using existing data and knowledge about the local climate.

It's a worthwhile activity, says Shem Wandiga, a professor of chemistry at the University of Nairobi's Institute for Climate Change and Adaptation in Kenya, who is not involved in any of the projects. "We do not know the cost of SRM and the impacts of items dispersed into the atmosphere. The technology is not yet developed, but it is good that we begin to think about it and study it," he says.

One African project will investigate how SRM could affect rainfall and river flow predictions in Benin, and more generally in West Africa, where climate change is expected to cause damaging flooding and coastal erosion as well as changes in the monsoon rain patterns. "We don't know if using stratospheric aerosol injection would minimise the risks of climate change—that is what we are trying to understand with our esearch," says Ezinvi Baloïtcha, a mathematical physicist at the University of Abomey-Calavi in Benin, who will lead the project.

In the second project, another West African team will model how injecting aerosols into the atmosphere could affect temperatures and rainfall in Central and West Africa, and its impact on water resources.

The third African project will be carried out by a team in South Africa. In Southern Africa, the lack of summer rainfall in 2015/16 led to food insecurity for 30 million people. Cape Town, where the researchers are based, nearly ran out of water last year following three consecutive winters of lower-than-usual rainfall. The researchers will examine the impacts of SRM on droughts and heat extremes around Southern Africa, which are still unclear.

"The project is based on the analysis of climate model simulations that take into account a world with and without SRM," says lead researcher Romaric Odoulami, who is based at the African Climate and Development Initiative at the University of Cape Town. "Our project will be a first step towards understanding the impacts of SRM on the climate in Southern Africa and the implications for the regional agricultural production."

A lifeline for industrialisation?

With all the uncertainty surrounding geoengineering and its effects, it might seem surprising that people are considering it at all. But there are possible benefits, apart from curbing climate change. One of the key advantages for developing countries is that it could give them more flexibility to continue with their industrial development, whereas other mechanisms for stemming climate change—such as radical and immediate reductions in greenhouse gases—could slam the breaks on industry.

This is an important consideration for Africa, says Samuel Okulony, a climate change expert at the Africa Institute for Energy Governance in Uganda. But SRM might be a very costly way for Africa to buy more time to industrialise, he adds. "Developing countries can both lose and gain with SRM."

There are certainly uncertainties about the physical impacts of SRM and whether it could end up being harmful, says SRM Governance Initiative's Parker. That's why it needs more research. The non-African DECIMALS projects will take place in Argentina, Bangladesh, Indonesia, Iran, and Jamaica. Together, all eight projects could provide data relevant to other tropical areas, says Parker. However, the results from the projects are only expected towards the end of 2020.

But the benefits of the projects will be more than just the data they produce, says Nelson Torto, executive director of the African Academy of Sciences based in Kenya. Torto was among a group of scientists who penned a comment piece in the journal Nature last year, calling for more research into the effects on SRM on developing countries. While Africa may not have the capacity to embark on geoengineering projects on its own, the continent can and should have a seat at the table where these issues are being discussed, he says.

The DECIMALS teams are also building vital research capacity, Parker says. Many of the teams involved have promising young scientists on board, and they are being encouraged to connect across projects and with the larger solar geoengineering research community, he says. "When these projects wrap up, there will be a new generation of solar geoengineering researchers distributed around the global south and well connected to the wider debate."

Esther Nakkazi is a freelance journalist based in Kampala, Uganda.

Saving Africa's wild larder

Photo Credit: Douglas Gritzmacher/USAID

Changes in land-use, population growth, and climate change spell trouble for wild plants that have fed Africans for centuries, writes Joseph Opoku Gakpo.

At Nyankpala, a small town in northern Ghana, forests that covered the surrounding countryside a century ago are no more. Thousands of hectares have given way to homes, businesses, roads, a university campus—even an agricultural research institution. But as the forests fell to the hands of developers and tractor blades, thousands of valuable Shea trees (*Vitellaria paradoxa*) disappeared too.

Emmanuel Chamba, a plant breeder based at the Savanna Agricultural Research Institute, has had a front row seat for the destruction. Oil from the Shea seeds played a central role in his childhood: The only cooking oil he ate as a child was from the Shea tree. "And if you had a sore on your legs, it was used as medicine," he recalls.

These days, Shea remains an important natural resource in Ghana. Shea nuts are used to make pomade, jam, and soap. The leaves are used for animal feed, and the bark and roots are given to cure diarrhoea among other ailments. In northern Ghana, an estimated one million women earn their livelihoods picking the nuts from the trees, which they process into Shea butter for the cosmetics and confectionery industries.

But Ghana's Shea trees—which only grow in the wild—are struggling to survive the onslaught of increasing urbanisation, charcoal production, commercial farming, drought, and wildfires. Ghana's forestry commission estimates that about 31% of the country's forests have been degraded, taking Shea trees along with them. As a result, Shea butter exports from Ghana declined from a record annual high of 397,000 tonnes in 2007 to 78,000 in 2016.

And climate change is making things worse. Temperatures in northern Ghana are rising to "unbearable levels", Chamba explains. And when it doesn't rain, Shea trees halt their flowering. "With most of the flowers aborting, then instead of 50 fruits, you end up with 10 fruits on the tree," he says sadly. He wants the government to grant Shea trees urgent legal protection. If not, "only God knows what will happen to the Shea", he says.

Wild and vulnerable

Shea trees are more vulnerable to the vagaries of human development and the climate than many other important plant-based resources because, unlike maize or wheat, they are not farmed. One of the reasons for this is that they take so long to grow, says Julius Yeboah, who heads the Bole substation of the Cocoa Research Institute of Ghana. Shea trees can take 20 years or more to begin producing fruit, he says.

It's also not the only non-cultivated plant in Africa struggling to survive. Scientists estimate that about 24,000 of the 31,000 plant species considered fit for human consumption on the continent are not formally grown. Their disappearance could hit poor and rural communities especially hard, as many are considered a 'poor man's food'. This is one of the reasons that scientists are becoming increasingly interested in studying them.

Bello Oluwasesan, a chemist at the Federal University Dutsin-Ma in Nigeria, is one of several researchers in his country cataloguing non-cultivated food plants. Like Chamba, he is concerned that some of them could go extinct as a result of industrial development, urbanisation, and climate change. "We want to study this group of plant species more, so as to show their importance beyond culinary uses," he says.

One of the species Oluwasesan studies is *Cyphostemma adenocaule*, a climbing plant whose leaves are used for soup and salad or cooked with beans in Ghana, Kenya, Uganda, and the Democratic Republic of the Congo. Their fruits are a delicacy in Côte d'Ivoire and Tanzania as well. But even though they can be grown moderately cheaply in poor soils, consumers across these countries prefer to pick them from the forests, he says.

Non-cultivated plants used in food and medicine often also have strong cultural significance. In northern Ghana, some ethnic groups use Shea branches to light fires to cook meals when important people die, says Alidu Abubakar, a climate change expert in Kumasi who formerly worked with Shea Network Ghana. It is a sign of reverence for the departed to have such a valuable species used to prepare the funeral meal.

Therefore, the loss of these plants could also lead to a loss of cultural heritage. Indeed, when asking about *Cyphostemma adenocaule* in his local town, Oluwasesan found only elderly people knew about the delicacy. Therefore, he says, it's high time to rediscover these plants. "This can provide huge benefits and opportunities for economic sustenance and food security for the poor and rural populace, especially the women farmers," he says.

As they become rare in the wild, scientists are redoubling their efforts to replenish stocks of non-cultivated crops like the Shea tree. Yeboah says he and colleagues at Bole substation are working on a project to produce more than 10,000 Shea seedlings with the help of the Food and Agriculture Organization. The seedlings need nursing for up to a year before they can be planted out, he says. These varieties will mature faster than their wild cousins, he says—just 10 to 12 years until fruits can be harvested.

However, there are no efforts to cultivate *Cyphostemma adenocaule*, Oluwasesan says. But he and many others hope these plants will not disappear. Otherwise, their flavour will no longer bring joy to the faces of the elderly in his hometown, he says. And that would be a sad spectacle for humanity.

Joseph Opoku Gakpo is a journalist based in Accra, Ghana, who covers environment, agriculture and rural development stories for Joy FM and Joy News TV.

Bello is the lead author on a review of Cyphostemma adenocaule published in Scientific African in March.

Link to this Scientific African paper:
https://www.sciencedirect.com/science/article/pii/S2468227618303247

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FEATURE

The promise and pitfalls of using AI to diagnose mental illness

Smart algorithms could soon help doctors diagnose neurological diseases like autism and schizophrenia. But will such tests be accurate in Africa? Sarah Wild reports.

No single human can monitor the brain's 86 billion neurons in real time, let alone the electrical impulses they send to each other. Even a team of people working 24 hours a day wouldn't manage this gargantuan task. But a machine could.

Scientists are using this fact to improve our ability to diagnose and treat mental health disorders like depression, schizophrenia, dementia, and autism—conditions that affect hundreds of millions of people globally, and which largely go untreated in many poor countries.

Currently, doctors diagnose schizophrenia and autism disorders by looking at their symptoms, which are not specific to each condition and include sensory processing problems and difficulties with social interaction. Often these symptoms overlap, even though the disorders have different treatments.

But researchers are also studying the brains of individuals with these conditions, to see if there are common patterns that could be used to diagnose disease.

"The idea is that we represent the brain as a network," says Alessandro Crimi, a researcher affiliated to both the University Hospital Zurich in Switzerland and the African Institute for Mathematical Sciences (AIMS) in Ghana. He says there are two ways to do this. "The one is functional, literally seeing where the blood is going in real time. The other is [to] look at the physical connections, the neurons." Either way, he says, the data is high dimensional, meaning that there is not only a lot of it but also a high number of variables.

That is where machine learning comes in. Machine learning is a subset of artificial intelligence (AI), which is when computers are used to perform tasks which were once thought to require human intelligence, such as decision-making and speech recognition. With machine learning, computers consume large quantities of data and learn from it, enabling them to detect hidden patterns in other data sets.

In a recent paper, published in Scientific African in March, Crimi and his AIMS co-authors from Ghana and Rwanda investigated the possible brain overlaps between schizophrenia and autism. They compared the MRI scans of 31 people with autism and 70 people with schizophrenia with control scans of healthy brains, analysing the connections between neurons. They found localised similarities in the brains of people with autism and schizophrenia, supporting similar findings by other groups.

Crimi says he will soon publish another paper in which he applies machine learning to Parkinson's Disease, looking at the brain connections of those with this neurodegenerative condition.

Modelling the brain is only one way in which machine learning is being used to understand patterns of neurological disease. Researchers at information technology giant IBM have found that the footprints of schizophrenia can be found in the way people speak.

"Psychosis has significant effects on language, to the extent that its disturbance is one of the principal components of diagnosis and prognosis," the IBM scientists explained in a paper, published last year in Frontiers in Human Neuroscience.

Using machine learning, the IBM team analysed the transcripts of interviews with 18 people diagnosed with recent-onset schizophrenia. They then compared their sentence formulation and language with 12 control subjects without the disease. Through identifying specific features common to those with schizophrenia, the researchers were able to predict who was afflicted with the condition.

IBM researchers are also using machine learning to detect, from people's blood, whether they have Alzheimer's disease. This degenerative disease causes a person's brain cells to waste away. The researchers are working to link proteins in a person's blood to biomarkers in their spinal fluid, which could be targeted by diagnostic tools.

Data sources matter

However, machine learning is only as good as the data that it is trained on. If that data is biased, so is the output. A 2016 ProPublica investigation found that trained software, used in the United States justice system, was biased against black people.

This is one of the reasons why this type of research needs to include diverse populations and to be performed in different paths of the world.

> **Machine learning is only as good as the data that it is trained on—and if that data is biased, so is the output."**

"AI machines use data and models to make predictions," explains Tshilidzi Marwala, an AI specialist and vice-chancellor of the University of Johannesburg in South Africa. "There is not nearly as much data collected in the African continent as in Europe, Asia and the Americas."

This results in AI machines having proportionally less African data to work on than data from the rest of the world. "The consequence of this is that machines perform [more] poorly when dealing with the African situations than situations from the rest of the world," he explains.

When it comes to neuroscience data sets, there is a strong bias towards people in Europe and the United States. Crimi and his colleagues used data sourced from laboratories in the US for their paper on schizophrenia and autism. But he says he does not believe running the study on data from Africa would produce meaningful differences.

"We're looking at an internal sector of the brain. I don't expect difference," he says, but agrees that more of this type of research should be done on local data. "There might be things that we're underestimating."

Marwala believes the lack of African data is an issue that requires attention as machine learning becomes more widely used. "We are developing AI models that assume [an] abundance of perfect and complete data, which is not the case in Africa. We need to have more AI experts to deal with the African problem of imperfect and incomplete data sets," he says.

And filling the data gap may be easier said than done, especially where data-gathering depends on expensive medical technologies. "Collecting MRIs in general is not cheap," says Crimi. A study published last year in The Pan-African Medical Journal found that in West Africa, a total of 84 MRI machines serviced more than 372 million people. "In Zurich, in the same university, you have three machines. The resources are not available [in African countries]," says Crimi.

Sarah Wild is a freelance journalist based in Johannesburg, South Africa.

Photo Credit: Mike MacKenzie
Image via www.vpnsrus.com

Fighting the fungus

Many African countries are working to curb the threat posed to human and animal health by mycotoxins. But climate change could set back their progress, Sharon Kantengwa reports.

Rwanda is building temporary maize driers to battle mycotoxins.

Photo Credit: Kelly Rwamapera

> Climate change will make the problem of mycotoxins in Africa much worse."

About 80% of East Africa's population depend on farming for their livelihood. For them, an ever-present scourge is mycotoxins—harmful substances produced by mould growing on cereal crops like maize, peanuts, cassava, and millet. These toxins are bad for human and animal health. They have been associated with cancer and liver disease, suppress the immune system, and can stunt the growth of children. When consumed in large quantities, they can kill both humans and livestock. Despite this, many farmers on the continent are not aware of their existence or possible consequences.

There are many initiatives to reduce mycotoxin contamination in African countries. But they face a new stumbling block: climate change. Models project that in the coming decades many hot and humid areas of the continent will get hotter and wetter as global temperatures rise due to human-linked greenhouse gas emissions.

"Climate change will make the problem of mycotoxins in Africa much worse," says Amare Ayalew, programme manager for the Partnership for Aflatoxin Control in Africa (PACA), a continental initiative to coordinate the control of aflatoxin—the most dangerous mycotoxin. Not only does increased humidity and warmth spur the growth of the toxin-producing moulds, but higher temperatures push the genes in the moulds that produce the toxins to express more frequently, says Ayalew who is based at the African Union headquarters in Addis Ababa, Ethiopia. Consequently, climate change could result in more mould, and also more toxins. This, he adds, represents a major threat to trade and food security on the continent.

An age-old threat

Mycotoxins entered the human food chain at about the same time as we began to farm crops and store them—something scientists estimate happened about 10,000 years ago. Stored grain provided a new ecological niche for fungi, and led to the proliferation of diseases like ergotism, which is caused by eating mouldy rye and which can trigger convulsions.

Sophisticated crop handling techniques have reduced the problem significantly in Western Europe and other developed regions. But across the developing world, mycotoxins remain a challenge. In 2015, the International Agency for Research on Cancer estimated that 500 million people across sub-Saharan Africa, Latin America, and Asia are exposed to dangerous levels of mycotoxins.

Many African countries have recently stepped up their fight against the scourge. Last year, Rwanda's Food and Drugs Authority (FDA) developed regulations governing food fortification, food-product labeling, registration, and hygiene. But some processors are violating the safety requirements by using substandard raw materials, says Charles Karangwa, acting director-general of Rwanda FDA. According to Minimex, a Rwandan maize producer, the level of aflatoxin in some of the local maize was more than five times higher than safe levels.

Intergovernmental organisation East African Community (EAC) last year also strengthened its plans to combat aflatoxin and agreed on a policy framework to deal more effectively with the threat it poses to human and animal health.

But some countries, like Uganda, don't have fully developed strategies for controlling mycotoxins. Such strategies are sorely needed, writes Fred Lukwago, a food scientist at the country's Makerere University in a 12-year review of Uganda's mycotoxin trends. The review, which was published in March 2019 in Scientific African, says that aflatoxin contamination costs the country almost US$600 million per year as a result of liver cancer cases—just one of the many health effects the toxins have in humans.

Lukwago and his co-authors, all from Makerere University, note that parts of Uganda will become hotter and more humid as a result of climate change. This will spur the proliferation of mycotoxins, they write, "yet there are no measures in place to mitigate the potential effects".

And some of the changes could be imminent. Rwanda is already experiencing increased extreme rainfall, and in Uganda climate change-related disasters like floods and landslides are occurring more frequently.

Possible solutions

However, Rwandan organisations and farmers are trialling solutions. A simple one involves improved methods of drying out crops. The Rwanda Agricultural Board is training farmers on the proper handling of maize, as well as organising an awareness campaign on aflatoxin, says Gilbert Rwaganje, a post-harvest handling specialist on the board. He says that the country has also mobilised the private sector to buy and introduce technologies that could assist, such as mobile dryers. "Currently, more than nine mobile dryers by private individuals are offering the services to different farmers."

Moses Ndayisenga, quality assurance officer at Minimex, says that they are also introducing new ways of drying maize. The traditional way of drying maize, by spreading the produce out on corrugated iron sheets and leaving them in the sun, is not sustainable, especially as rain patterns are becoming unpredictable. At the moment, more than 3,000 temporary drying facilities are being constructed in collaboration with farmer cooperatives and local government, Ndayisenga says.

But in the absence of advanced mechanical dryers like the ones used in developed countries, Rwanda and many other African countries will continue to suffer aflatoxin attacks, says Kirimi Sindi, a food scientist in Kigali. "In the developed world they have mechanical dryers [...] to dry to the required moisture level. In Rwanda and in many African countries, we don't have these because the cost of energy is high."

There's another solution that's also being investigated: Aflasafe. Aflasafe, developed by the International Institute of Tropical Agriculture (IITA) in Nigeria with funding from development funders in United States, Germany, and Austria, is a harmless type of *Aspergillus flavus*, the same fungus that produces aflatoxin. When sprayed onto grains, Alfasafe prevents its more dangerous cousin from taking root, and reduces aflatoxins levels in maize and groundnuts by 80% to 100%.

In Rwanda, the Alliance for a Green Revolution in Africa last year gave a grant to the IITA and the Rwanda Agricultural Board to set up a factory to produce Aflasafe in Rwanda, in partnership with the country's agriculture and animal resources ministry. The three-year grant, which began in January, is expected to lead to local trials of the product before the middle of next year.

Partnership for Aflatoxin Control in Africa's Ayelew believes that farmers will remain at the frontline of aflatoxin control and that they need to be better informed.

As countries like Uganda and Rwanda fight the toxins, their experiences could—perhaps surprisingly—turn out to be useful for developed countries that thought they'd solved the problem long ago. In 2017 a pair of scientists from Australia and Canada warned that with climate change some fungal toxins that "might have been rare in their working careers can reappear".

In other words, mycotoxins could once more become everybody's problem—and this time perhaps Africa could lead the fight.

Sharon Kantengwa is a reporter for The New Times newspaper and is based in Rwanda.

Photo Credit: WFP/Jonathan Eng

Digging for gold in Africa's garbage

Landfills—those smelly, polluted no-man's-lands of modern life—often contain useful raw materials. Recycling them for profit presents opportunities and challenges for Africa, Eman El-Sherbiny reports.

Just a bus ride away from the shimmering Nile-side skyscrapers of central Cairo lies Hay el-Zabaleen. Known locally as Garbage City, it's where the unwanted clothes, food and, all too often, people end up from the expanding mega city. Here, the poorest of the city's poor carve a meagre existence by salvaging what they can from castaway plastics, metal, and textiles.

Egypt's practice of waste-picking is old. But it's being brought into the 21st century in a number of countries around the world in the guise of 'landfill mining'. This is the process of using advanced separation and processing technology to extract reclaimable resources from dumps. Israel started it in 1953, extracting fertilizers from a Tel Aviv landfill. In the 1990s interest in the practice grew in the United States, as a result of stricter environmental laws and the need to clear space for new waste.

Now, interest in the practice is growing once more. The wealth of metals and fuel that can be obtained from dumps are attractive to companies and governments, especially given the ever-rising prices of oil and other raw materials. The potential is huge: For example, Belgium's Remo landfill outside Ghent could produce enough fuel to power 200,000 homes for 20 years, and Europe has many hundreds of thousands of such landfills.

Although Africa's waste mountains are growing, formal landfill mining remains rare in Africa. That could change, however, if the wealth in Africa's dumps catches investors' attention. That might take some doing. For the most part, little is known about the contents of African landfills. But in Ghana, pioneering scientists have begun to dig deep.

Geo-environmental engineer Frederick Owuso-Nimo from Kwame Nkrumah University of Science and Technology in Kumasi has studied the city's Oti landfill to examine its components, characteristics and operational management. He and his colleagues published their results in Scientific African in March. The study could be used by prospective landfill miners to inform their plans—but also provides a valuable snapshot of an active African landfill.

Oti is one of Ghana's few engineered landfills. That means it has been planned and structured in such a way that it avoids contaminating the groundwater or soil. It was chosen for the study because of its proximity to the university and because it is one of the earliest commissioned landfills in Ghana.

Sampling the landfill at different locations and depths, Owuso-Nimo and his team found that decomposed organic materials, or DOMs, contributed the most to the landfill site, followed by combustibles including plastics, wood and textiles. They found a plethora of materials that landfill mining could profitably extract, including metals, leather, glass, as well as DOMs and plastics. But they stopped short of analysing the profitability of such a venture.

Mining landfills could be profitable in Kenya, says Nairobi-based environmental engineer, Valentina Zafra. Kenya produces 680 million tonnes of waste every year and its biggest and most hazardous landfill is the Dandora dumpsite in Nairobi. As in Egypt, the 30-acre landfill serves as an indirect source of income for scavengers who largely overlook the health risks to rummage for precious or scrap metals, plastics and food.

"The materials that can be the most lucrative to extract are metal, ceramic, glass as well as plastic, wood, and cardboard," Zafra says. She believes studies like the one done in Kumasi would be valuable for Kenya. "We really do not know for sure what is in a landfill, other than it is a mix of domestic, industrial and commercial waste," she says. Such studies could help city planners better plan their waste management, she adds.

More than money

Financial gain is just one of the reasons Africans might want to consider landfill mining. There is also growing pressure on land around the continent, and landfill mining could help clear valuable space for new garbage, or even for development. It can also extend a landfill's lifetime. For example, Oti was built in 2004 to take the city's waste over 15 years. It should have been full this year but as a result of to compaction techniques used to flatten the landfill content and existing recycling activities, it is still able to receive municipal solid waste. Landfill mining could extend this further.

But there are possible barriers to developing sustainable and clean landfill mining in Africa, says Zafra. These include the level of technology needed to separate materials, the cost of the extraction technology (which is sizeable) and natural fluctuations in the market price of natural resources.

Done incorrectly, landfill mining can also itself be hazardous to the people doing it and communities living around the landfill. Parts of a landfill can be prone to collapse, and anaerobic reactions within the waste piles could produce methane and carbon dioxide, making landfills prone to explosions. In Europe, there are strict rules for companies looking to secure landfill mining licenses—Africa would need the same.

Of course, waste pickers all over the continent brave these dangers every day. For them, formal landfill mining brings another potential concern: it could rob them of their livelihood. Owuso-Nimo agrees this could be an unintended consequence. But, he says, the two processes could also be complementary. "Note, the scavengers mostly operate at the time of deposition where they take the part of the waste valuable to them," he says.

One solution would be to combine the ancient practice with the new, benefiting everyone, he adds. The landfill mining industry could recruit the waste-pickers and train them to become part of their process. "After all, that is what they do and know best."

Eman El-Sherbiny is an Egyptian freelance journalist who splits her time between Cairo and Nairobi.

Ghanaians working in Agbogbloshie, a suburb of Accra, Ghana.

Photo Credit: Marlenenapoli [CC0]

Formal landfill mining remains rare in Africa. But that could change."

Helping little girls grow tall, one dead weevil at a time

Photo Credit: Google Stock

By Mojisola Esther Karigidi

When I was a little girl, I could abandon a whole meal at the sight of an insect on my plate. My mother would do her best to make sure that our meals were kept away from ants but, somehow, she couldn't manage to prevent dead cowpea weevils (*Callosobruchus maculatus*) from appearing in our cooked cowpeas, which we call beans. The meal was our dinner four times a week and mum said the protein in the beans would make us grow tall and keep our skin shiny.

I liked the idea of growing tall and having healthy skin, but watching out for dead weevils in my food was discouraging. To help me overcome my reservations, my mum told me that the weevils were responsible for the beans' protein benefits. But I later realised that my parents were as troubled as I was by the insects. They bought beans in smaller quantities from the market so we could finish them before the weevils began to proliferate, but that led to a reduction in the number of times we had beans for dinner.

Weevils create a horrible sight when they emerge from stored beans. The pests, which breathe and excrete in and amongst the cowpeas, cause mould to grow in a container of infested beans. Those moulds, in turn, produce poisonous substances that can make people sick. The thought of consuming weevil waste and microbes along with a nutritious meal is not appealing.

> Weevils create a horrible sight. They cause mould to grow which produces poisonous substances that can make people sick."

But that's not the only way weevils harm beans. The larvae bore into the beans to feed, piercing the seed coat and creating holes that tarnish the appearance of the beans and reduce their quality. Left to their own devices, weevils can reduce a bag of beans to powder, rendering them completely unfit for consumption. Even at this point, weevils are unrepentant. They leave the container to search for fresh beans on which they can lay more eggs.

> When I saw that people planted lemongrass to repel reptiles, my first thought was if it could get rid of weevils too."

The terror of weevils affects everyone: households, farmers, and traders. In developing countries where farmers and traders often lack formal education, they indiscriminately use insecticides to kill weevils or to prevent them from attacking their crops to eliminate losses. In my country, Nigeria, some traders use toxic substances which are not meant to be applied to food to get rid of weevils. Chemicals of this nature are bad for human health because they can cause damage to the respiratory, cardiovascular, and central nervous systems. They can also cause cancerous cells to develop in organs like the colon, prostate, thyroid, lungs, and liver.

As an adult and a trained scientist, I wanted to find alternative methods of dealing with weevils. I sought a pesticide that did not harm humans, animals, or the environment, and I looked to plants to find it. People have long used natural methods to combat pests. So when I saw that some people planted lemongrass (*Cymbopogon citratus*) around their homes to repel reptiles, my first thought was if it could get rid of weevils too. It became a pet project, which I continued with during my Masters programme at the University of Ibadan, Nigeria.

Weevils attack grains and pulses in storage, not just beans. Helped by my mentor Adegoke Adegbite, my team members and I got to work in the laboratory where we reared large numbers of weevils for the study. We then distilled a fluid from a decoction of lemongrass leaves and exposed adult weevils to it. The results were impressive: About 70% of the weevils died within two to three hours of exposure.

To kill more of the bugs more quickly, we obtained distillate from other insecticidal plant parts—like orange peel—to boost the effect. We combined the plant distillates in different proportions with lemongrass as the chief component and made a biopesticide, which killed 100% of adult weevils within an hour of application.

We also investigated our biopesticide's ability to prevent weevil eggs from maturing. We let female weevils lay eggs on clean seeds, divided the seeds with visible weevil eggs into groups, treated them with different concentrations of the formulation, and then incubated them in the dark for eight weeks at room temperature. At the end of the incubation period, none of the treated seed groups had larvae or adult weevils, while the untreated control group showed 70% adult weevil emergence.

But while our product can kill weevils in infested grains, it works best as a preventative measure on newly harvested beans and maize since that requires less of the product. The formulation can preserve treated seeds and grains for up to a year and a half without reapplication. Synthetic pesticides, on the other hand, require reapplication after two to three months. Also, the product has a pleasant lemony smell that doesn't affect the taste of beans when used in small quantities.

The product has been patented, and we are looking to license it to an interested organic pesticide company for commercialisation. But the discovery has had benefits closer to home as well: When I told my mum that children who want to eat beans to get shiny skin and grow tall won't have to worry about weevils or chemicals anymore she stared at me, grinning from ear to ear.

Mojisola Esther Karigidi is a Nigerian biochemist and entrepreneur, and the founder of Moepelorse Bio Resources, a start-up venture for the production, sale, and distribution of environmentally-friendly organic pesticides.

Moving from goodwill to action: A call for a Coordinated Vision for Africa's Digital Economy

Dr. Youssef Travaly, Nathalie Munyampenda & Esther Kunda

In 2016, during the World Economic Forum, world and business leaders agreed that the Fourth Industrial Revolution had arrived, and that it would fundamentally change the world as we know it. Africa has been missing in action in the previous three industrial revolutions. The Fourth Industrial Revolution provides Africa the opportunity to jumpstart out of poverty using technology, digital technology, to accelerate economic development of the continent.

New digital trends are already radically transforming the business landscape, reshaping the nature of work and the structure of enterprises, spurring innovation both in services and business models. The new digital age is also making knowledge ubiquitous and enabling access to international markets.

There is compelling evidence that the use of digital technologies will create new opportunities for economic growth, greater innovation and boost Africa's global competitiveness, whilst supporting its market integration and transition to knowledge-based economies. The digital economy is already the single most important driver of innovation, competitiveness and growth in Africa despite the fact that almost half of African countries are low-income countries with a GDP per capita of less than $1035.

Africa has already made impressive innovative advances with rapid adoption of mobile and smartphones and more importantly with financial services such as M-Pesa that have revolutionized financial inclusion for the unbanked. Nevertheless, basic digital infrastructure such as data is still very expensive in Africa with some countries reaching $20/Gb. As well, basic infrastructure like electricity and roads are still inadequate especially in rural parts of Africa, leaving millions of Africans out of reach of potential economic opportunities.

The African Union (AU) and African Governments and entities like the World Bank and Smart Africa and others have already realised the importance of the digital economy and its potential in accelerating the development of Africa. They have made significant commitments to invest and provide support to initiatives that are supporting the rapid digitalisation of African countries. Spearheaded by the World Bank, the Digital Economy Moonshot was recently launched to support the implementation of basic digital infrastructure in African countries and ensure access to network, digital devices and services. The AU, UN Economic Commission for Africa and other UN bodies like the ITU as well as Smart Africa are also working on digital identity projects, one area network and e-government services to accelerate the digitalisation of services and access to digital services.

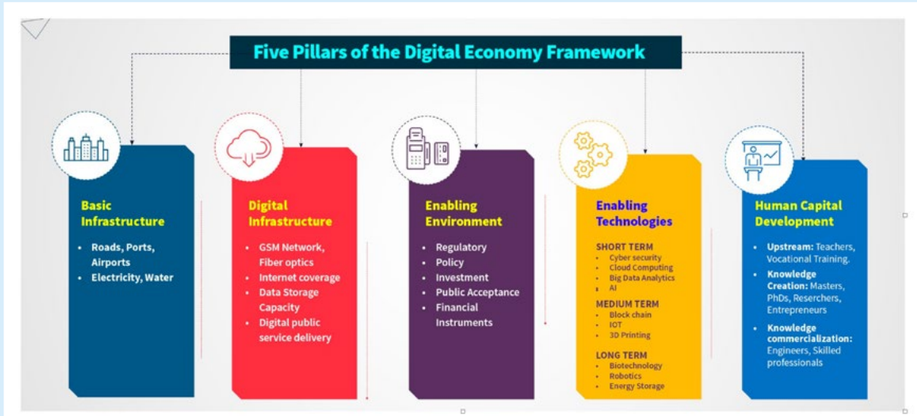
With all these important and groundbreaking initiatives to accelerate the digital economy, there is a need to have a Pan-African vision and an operational roadmap for Africa's digital economy. Establishing and harmonising policies and implementation strategies that take into account economic blocs as well as continent wide projects is very crucial as this will accelerate cross-border economic activities.

Proposing a pan-African vision for the digital economy

Over the last eighteen months, the Next Einstein Forum has been working on a Pan-African operational roadmap for the digital economy 2020-2050. This roadmap is preceded by a draft common vision for the digital economy from an African perspective.

On this, we developed a conceptual framework to guide this process. The proposed framework is dynamic, with interlinked building blocks, to account for the specific and varied levels of development at a country level as well as infusing a continental perspective.

This framework proposes five building blocks or pillars that support the development of a thriving digital economy. The framework recognises that despite the capabilities of Africa to leapfrog, basic infrastructure is an undeniable necessity, one that governments should focus on. This requires innovative funding instruments to support rapid



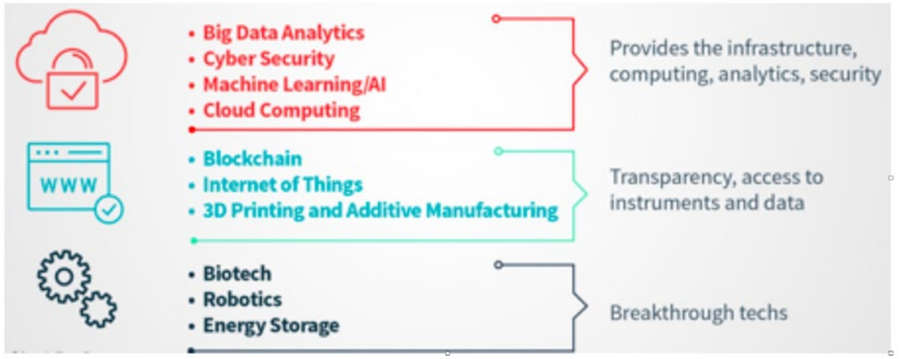
Source: Next Einstein Forum

infrastructure expansion that includes digital infrastructure.

An enabling environment requires the harmonisation of current policies and regulations across African countries. Data protection laws, digital identity framework and country sovereignty, among other concepts that need rapid establishment will need to be country specific but also factor in continental integration. African countries need to ensure that there is a growing emphasis on policies that look at the long term as well as having an operational roadmap towards implementation. This will be greatly accelerated by the early engagement of the private sector in conceptualisation of the digital economy ecosystem.

The digital economy relies on emerging technologies and the Next Einstein Forum (NEF) in consultation with the NEF Community of Scientists, who are among the leading African scientists and researchers, proposed the most important technologies that African countries should focus on both in the immediate and long term.

But these technologies cannot be harnessed without the talent to create and harness technology. The lack of strategies that enable research and easy piloting of innovation in Africa is a concern. Developing innovative funding instruments that support research and development as well as scaling up of innovative projects will accelerate the industrialization of African countries.



Source: Next Einstein Forum

Skills, skills, skills

This brings in a key area: Human capital development. As we know, the digital economy has the potential to unlock millions of jobs with 85% of the jobs in 2030 not yet invented. This implies that the future of work is uncertain and we need to prepare young people with agile creative and problem solving skills as well as the ability to adapt to new situations to prepare young people to meet market needs and create new markets. This requires a robust education ecosystem to provide these competencies and skills. Here again, the private sector can play a key role in shaping this education ecosystem by investing and partnering with higher learning institutions on research and development. The private sector can also provide internships and support other forms of work integrated options etc. The key here is view it as 'building the talent you need'.

Quick wins, long term gains

On the above framework, we believe African countries and other Pan-African entities should create consortiums alongside each pillar of the framework in order to accelerate the digitisation of various economic sectors especially in the areas where they are already heavily investing in and supporting. Such examples would include entities like the World Bank and African Development Bank continuing to support the rapid development of basic infrastructure for African countries with emphasis on removing siloed projects that do not create continent wide infrastructure. Institutions like Smart Africa, which is spearheading the One Area Network initiative and other initiatives that support bringing digital infrastructures to all Africans at an affordable cost could partner with likeminded institutions to support the development of digital infrastructures across Africa. Higher learning institutions and training companies like the African Institute for Mathematical Sciences (AIMS), Carnegie Mellon University Africa, Andela are already experimenting and succeeding at producing qualified African talents in emerging technologies like AI, data science, cybersecurity, to name a few. These institutions are well positioned to create a consortium and develop an operational roadmap for human capital development.

These are some tangible and quick wins for the entire continent to build up on the individual efforts that are being implemented to accelerate the digital transformation of Africa.

The Next Einstein Forum has been working on used cases and operational roadmaps for various economic sectors like health, agriculture, trade, to name a few. We will continue to build on these efforts seeking input from academic, public and private actors.

Our formula is simple. We are encouraging governments, development bodies and the private sector to endorse the proposed digital economy vision, invest in basic and digital infrastructure, align policies and investment instruments, invest in research and development to create African solutions by developing a robust human capital pipeline with the goal of accelerating African countries' economic development.

With all these important and groundbreaking initiatives to accelerate the digital economy, there is a need to have a Pan-African vision and an operational roadmap for Africa's digital economy

The case of trade and logistics through the African Continental Free Trade Area (AfCFTA)

On 30 May 2019, the AfCFTA will go into effect following ratification by 22 African countries. The momentous agreement will create the largest trade zone in the world. The AfCFTA's main objective is to increase intra-African trade and reduce trade barriers such as tariffs on 90% of goods by 2022.

In order to accelerate the free trade area, there is need to digitise most of the services and procedures in the trade and logistics sector. Some countries have already started implementing interesting projects to accelerate intra-country trade such as East African countries with the electronic cargo tracking system implemented across all countries. Other countries have implemented cargo tracking in their own countries but some of the biggest challenges will be harmonising different policies and regulations across neighboring countries. This calls for pan-African trade regulations.

If the goal is to eliminate 90% of tariff barriers by 2022, we have some ways to go. Today, classification of most goods is subject to individual countries. It is in this area that we urgently need a Pan-African consortium that would harmonise most of the goods across Africa to ensure that exemptions are similar and defined in the same way across Africa.

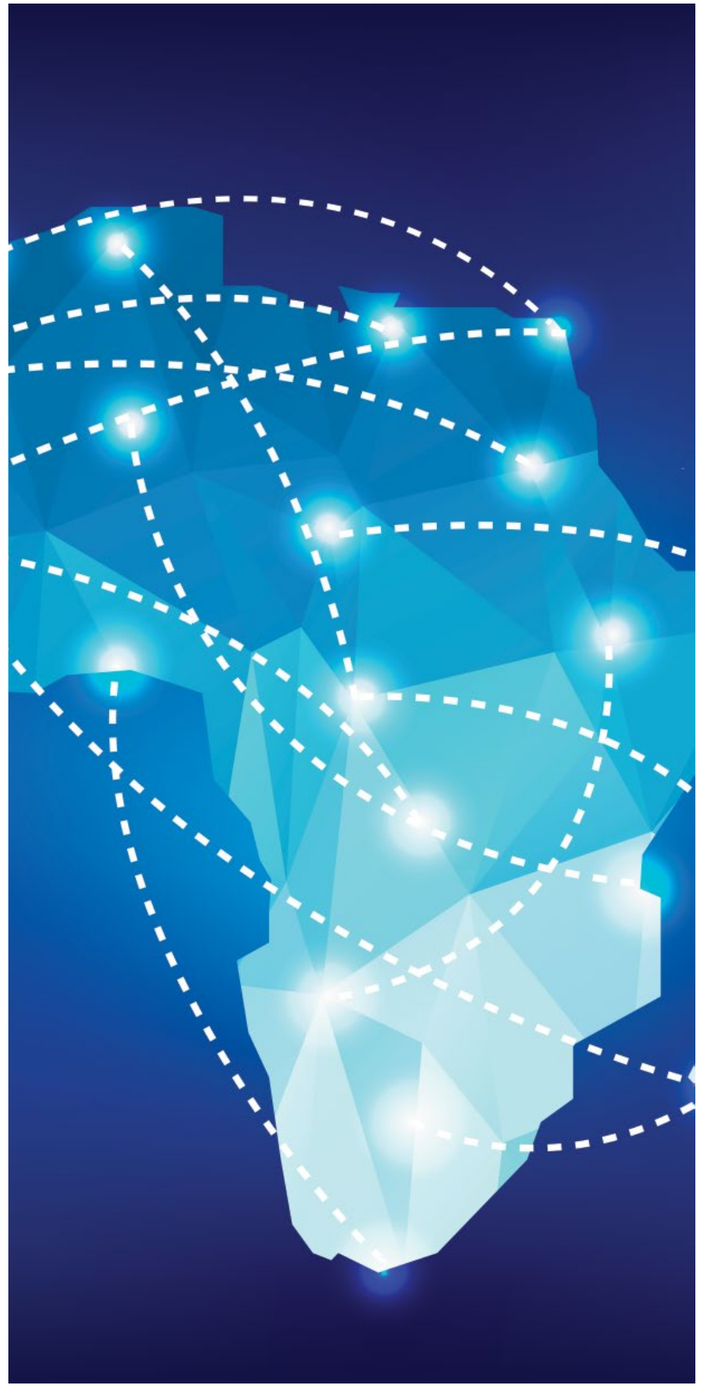
Trust across the trade value chain process is going to be an important factor to ensure that the AfCFTA succeeds. For that, there is need to create transparency along the value chain. Companies like IBM have already been experimenting using Blockchain to create transparency from source or farmer to destination or final buyer on a supermarket shelf. For example, IBM in partnered with Maersk to pilot Blockchain in the flower exporting business in Kenya. The intent is to try and reduce the potential for human errors, fraud and cost savings which could indirectly reduce the shipment time for several products. These are some of the pilots being rolled out but regulations need to catch up to enable large scale demonstration in various African countries.

Digital must build on basic infrastructure

Other than regulation, African countries should not neglect basic infrastructure to rely solely on the "digitisation" of various sectors. There is a clear need to improve inter-country road networks, increase access to electricity to millions of Africans, increase connectivity to allow these advances to reach rural areas in several countries and more importantly create Pan-African border policies to allow movement of people and goods.

By 2030, it is estimated that Africa's household consumption will be $2.5 trillion. If the AfCFTA is properly implemented and we reach the set goals by 2022, Africa will be an undeniable market. For that, African countries should be the first beneficiaries by creating the appropriate industries, innovating across all the key enabling technologies and more importantly transitioning African countries to digital economies which will accelerate their economic growth to middle income status.

Dr. Youssef Travaly, a physicist and material scientist, is Vice-President of Science, Innovation and Partnerships at the Next Einstein Forum. Nathalie Munyampenda is Managing Director of the Next Einstein Forum. Esther Kunda, a computer scientist, manages policy, innovation and the Community of Scientists at the Next Einstein Forum.



On Science and Homecoming: A diaspora African's view

Photo Credit: Mark Hartman/ScienceLink

Neither guilt nor sentimentalism should drive an African diaspora scientist's choice to return home, writes Sara Suliman, a postdoctoral researcher at Harvard University in the United States.

Africa's global diaspora harbours a disproportionate share of the continent's top scholars and thought leaders. In 2014, the United States Census Bureau reported that Africa-born immigrants had the highest educational attainment in the country, adjusted for their population size, compared to other foreign-born immigrants.

This concentration of credentials in the US alone renders Africa's diaspora an untapped resource for developing researchers and professionals in science, technology, engineering and mathematics (STEM) fields in African countries.

But what should drive their choice to go back home? What does 'home' mean to them anyway? And what internal resolve and external support are needed to make sure such transitions are successful? As a diaspora scientist myself living in the US and studying tuberculosis, which disproportionately affects Africa, this is something I have pondered.

I was born in Sudan and my family has strong ties to the continent. But I spent the vast majority of my life between the Middle East and North America—places my family, like many others, moved to in order to endow us with better economic and educational opportunities. Although my ties to Africa remained relatively strong, I often considered my position of relative privilege and how to channel it to serve Africa without feeding into the narcissistic 'saviour' trope.

Consequently, I spent a few years in South Africa where I realised the potential, and also limitations, of my contributions as a junior African scientist. But although South Africa was not home, it was still an African country, and I felt a little guilty when I later pursued an opportunity in the US. I convinced myself that it was a necessary step and that I would return after establishing a solid network and developing my expertise. Nevertheless, I was also aware that many well-intentioned African scientists had left before me and never returned. I feared I would become another statistic.

Reasons to leave

I know I'm not alone. Many of my diaspora friends and colleagues grapple with the same feelings of longing and guilt. On the face of it, conditions for our return have never been better. We are living through a period of unprecedented growth in STEM innovation in Africa. Research output between 2003-2012 effectively doubled compared to the previous decade, and it continues to grow exponentially. A lot of growth is still needed: Sub-Saharan African research still accounts for less than 1% of the world's output, although the region accounts for 14% of its people. To increase this proportion, Africa needs a lot more scientists.

But there are still good reasons to leave, at least temporarily. Junior African scientists are expected to spend more time on infrastructure and capacity development than young researchers in wealthier parts of the world while scavenging for resources, sometimes within very challenging political and economic contexts. This can curtail their scientific productivity.

By contrast, if they go overseas they will have access to better equipment,

> There are still good reasons to leave, at least temporarily."

build networks, and learn how to compete for funding—things that will position them better to contribute meaningfully when they do return. One example of this is Zambian chemistry professor Kelly Chibale who built a network of academic and industry partners during the early stages of his career in the United Kingdom and US, which he later mobilised to build the state-of-the-art H3D Center in Cape Town, South Africa. It is the largest drug discovery unit on African soil.

And for those of us pondering whether to return, there is further complexity. In post-colonial Africa, artificial borders drawn up by colonists became the boundaries of modern-day countries. We may claim one of these countries as home by virtue of our place of birth, passports, or parental ancestry. But our desire for 'home' may not be about returning to a particular country.

Some diaspora scientists may feel that their best way of giving back to the continent is to relocate to one of its scientific centres of excellence, even if it is not located in their country of birth. Many young scientists move within Africa to work at these institutions, creating an intra-African diaspora which can be harnessed for continent-wide STEM development. One of them is One Dintwe from Botswana, a research officer at the Cape Town HIV Trials Network Immunology Laboratory. She says that in South Africa she can build capacity in Africa for Africans. There is more room to grow and shape how science evolves on the continent there than in places where research is more advanced, she says.

More support needed

Unfortunately, there are few mentors who can encourage young scientists to take advantage of the opportunities presented by the intra-African diaspora for collective African benefit. I, for one, would like to see a wider discussion about this collective benefit of scientific mobility within Africa. This could shape research into pressing issues like healthcare systems, infectious disease control, mass urbanisation, and climate change—topics that require a regional mindset that transcends national African borders while acknowledging the diversity of local realities.

There isn't a universal formula for the trajectory of young African scientists, particularly when personal circumstances colour the choice and desire to stay or leave. African diaspora scientists shouldn't feel that they need to return home out of a sense of guilt or as a reactionary response to pan-African sentimentalism. Instead, we should think about our desire to return in terms of strategic steps that actually improve STEM capacity and research output in Africa. In practice, returning to take up leadership positions in institutions where the infrastructure is reasonable, and where we can train younger scientists while exercising real agency over the research agenda, is bound to be more fruitful than moves rooted in sentimentalism.

Importantly, diaspora scientists can't do it alone. Policymakers in Africa need to address the reasons behind the current exodus of African scientists and facilitate funding streams to create sustainable opportunities, retain young scientists, and facilitate their work of advancing STEM in Africa. Local institutions need to devise career trajectories to help diaspora scientists integrate upon their return. But these programmes must also be flexible enough to acknowledge that our reasons for returning could be as different as the reasons we departed in the first place.

> Conditions for our return have never been better. Africa's research output between 2003–2012 effectively doubled compared to the previous decade, and it continues to grow exponentially."

Sara Suliman is a post-doctoral fellow studying the immunology of tuberculosis at Harvard Medical School in the United States

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