We are living in a world beyond what we ever thought possible – a world Beyond Imagining. Everything that once felt certain has been destabilised: how we move about our communities, cities and the world; how we work; how we educate our children; and how we plan for the future. In our new world, nothing is as it was.

In times like these, the creativity and innovation that defines the Fourth Industrial Revolution (4IR) is more critical than ever before. We need new solutions to solve unprecedented problems, and we need them to help make our world sustainable in the long term.

Welcome to the latest edition of Beyond Imagining, a 4IR-focused publication brought to you by the University of Johannesburg (UJ). In this edition, we are looking at the ways in which 4IR is being used to address a myriad of challenges faced by the planet and her people – not only in the Covid-19 era, but well beyond. The pursuit of these innovations is nothing less than the creation of a sustainable earth.
In the 260 years since the start of the First Industrial Revolution, our world has changed dramatically. Of course, significant shifts took place in the centuries prior, but the late eighteenth and early nineteenth centuries brought with them such massive and rapid transformation as to alter humanity and our planet forever. Machines replaced manual methods in almost every industry. New energy sources, such as coal, steam, electricity and petroleum, became commonplace. Factories sprung up overnight. Mass urbanisation led to the rise of some of the world’s largest cities. Global population growth became exponential.

The impact wrought on the planet as a result of these changes, and the many that have come since, was and continues to be immense. We have exploited our natural resources to the detriment of the environment; polluted our land, water and air; irrevocably contributed to climate change; and established huge disparities between people, both economically and socially. We have created a world that, in almost every respect, is unsustainable.

As we look to the future, it is clear that we need to use the advances of the latest industrial revolution, 4IR, to create a healthier, more sustainable earth. But how do we go about this Herculean task? The pages that follow may offer a glimpse.

Creating a sustainable earth through 4IR.
The intersection of agriculture and AI in Africa.

Perhaps the largest cause for concern in Africa right now is its agricultural sector, where climate change is having a devastating effect.

A study by McKinsey & Company found that more than 60% of sub-Saharan Africa’s population comprise smallholder farmers, and about 23% of its GDP comes from agriculture. But increases in temperature, changes in precipitation patterns, and the rise of extreme weather events are disrupting entire industries, reducing food availability and impacting food quality. This is particularly concerning considering that Africa houses the world’s fastest growing population.

How, amid such overwhelming circumstances, do we see the continent reach its potential, not only in addressing food security but also in becoming an important player in the global food market? The answer, says UJ Vice-Chancellor Professor Tshilidzi Marwala, lies in the technologies of 4IR.

Artificial intelligence (AI) offers massive opportunities for the agricultural sector. “Farmers can tap into AI to combat diseases and pests, which have been worsened by climate change and pesticide use,” Professor Marwala explains. “And drones and other robots equipped with computer vision can collect data points from farms’ existing crops.”

South African AI software Airlitix is currently being used in drones to automate greenhouse management processes. “This could be taken further,” he says. “Airlitix could also be used to collect temperature, humidity and carbon dioxide data, as well as analyse soil and crop health.”

Similar technology has been adopted elsewhere. The ThirdEye project in Kenya uses near-infrared cameras mounted on drones to survey and diagnose pests and diseases, water stress and nutrient deficiencies. This requires a combination of historical data and the use of AI.

“As we look forward – to a sustainable earth and a green economy – 4IR doesn’t only provide tools for efficiency, but also presents a unique opportunity to interrogate how we can transform the industry amid a troubled natural environment,” says Professor Marwala.
Gwakwani: South Africa’s first smart rural village.

In South Africa’s north-east corner, not far from the borders of Zimbabwe and Mozambique, 100 people call the remote village of Gwakwani home. For years, Gwakwani was so isolated as to be beyond the influence of the 20th, let alone the 21st, century. It had no running water and electricity. Cell phone reception was patchy at best and internet access non-existent. The nearest essential services, such as schools and clinics, were – and still are – located between 6km and 20km away.

But the village’s fortunes changed in 2014, when UJ’s School of Electrical Engineering started to work with the chief and local council to introduce critical improvements.

Clear here to view a video on UJ’s work in Gwakwani.

WATER, LIGHTS AND OVENS FULL OF BREAD

“We started by replacing Gwakwani’s diesel borehole pump with a solar borehole pump, and built a network of taps and tanks,” says Cornay Keefer, the School of Electrical Engineering’s project manager. “This was followed by the installation of solar lights in the villagers’ homes, as well as solar streetlights.”

After lighting came economic empowerment. Gwakwani’s remoteness makes earning an income difficult and unemployment is high. The electrical engineering team got to work creating a solar bakery, where bread and other baked goods are now made and sold. Large cold storage units have also been installed, and a solar-powered creche has been built for the village’s youngest residents.

“Sensors have been put in place all over the village and this data is fed back to a system I can monitor and control from UJ. I can see when the pressure in the water tanks is running low, what the ambient temperature inside the cold storage units is, and when the borehole pump is experiencing issues,” Cornay explains.

These remote monitoring solutions are made possible through an Internet of Things (IoT) network connection that UJ has developed in partnership with global communications provider Sigfox.
RURAL, REMOTE AND SMART

While the technology being used in Gwakwani is not necessarily at the cutting edge of 4IR, the environment in which it has been installed makes it unique — and profoundly meaningful. “I think what’s interesting is that we’re using basic 4IR in an area that has never had access to any form of technology before,” says Professor Suné von Solms, associate professor at the School of Electrical Engineering.

Children who previously had never flicked a light switch are now learning English through the television at the crèche, school-going children are able to do their homework beneath bright lights, and eight people are employed at the bakery full time. Just a few years ago, none of this technology existed.

The result is a smart, IoT village that operates without municipal infrastructure and meets the economic and social needs of its residents — not only in the short term, but on an ongoing basis.  

Being able to monitor what’s happening in Gwakwani using 4IR technologies makes this project sustainable, and that’s what we’re after: its long-term success. – Prof. Johan Meyer, head of the School of Electrical Engineering.

GWAKWANI AND BEYOND

In recent months, a community development trust — not just for the village, but for the region — has been established through the Industrial Development Corporation. A total of R5 million has been promised, which will be used to implement a community development plan that will benefit several villages in the area. Gwakwani — and the 4IR advances that have been used to address some of its most urgent needs — is just the beginning.
4IR helps to boost South Africa’s mining sector.

Since 2014, the DSI-NRF Centre of Excellence for Integrated Mineral and Energy Resource Analysis (CIMERA) has studied the origin, distribution and character of earth’s mineral and fossil fuel resource systems. Its aim is to ensure that these systems are used sustainably, not only in South Africa, but across the African continent.

Hosted by UJ, and co-hosted by Wits University, CIMERA focuses on high-quality and world-leading basic and applied research, and on developing the people who work in this field. Many of its 69 projects use advances in technology to make the sector greener, safer, more efficient and more cost effective — in a word, more sustainable.

The following projects offer just a glimpse of the ways in which CIMERA is using 4IR to improve one of South Africa’s most important industries:

- **THE HYPERSPECTRAL IMAGING OF COAL CORES**
  Coal exploration and quality assessment is an expensive and time-consuming exercise. But if the hyperspectral scanning of coal cores provides enough information on coal quality and washability, then it has the potential to save the coal mining industry a significant amount of time and money.

- **THE POTENTIAL OF MULTI-SENSOR REMOTELY PILOTED AIRCRAFT SYSTEMS**
  New methods of mining exploration are required to increase efficiencies, reduce costs, ensure maximum personal safety and secure public buy-in. The use of multi-scale remote sensing techniques is being considered to improve efficiencies and minimise the footprint of exploration.

- **REPROCESSING LEGACY SEISMIC REFLECTION DATA**
  The seismic reflection method is a valuable, but expensive, tool for discovering and quantifying major mineral deposits and hydrocarbons. To maximise its potential, legacy data can be reprocessed using modern processing techniques.

Click here to view drone footage of the Swakop River.
Unhealthy food choices, obesity levels, and the risk of food-related non-communicable diseases are on the rise across the world, including South Africa. Many of us opt for convenient, processed foods that are high in sugar and fat and low in nutritional content, and then have to deal with the adverse health effects. At present, both the consumption and production of the food we’re eating is unsustainable — and it’s taking its toll on our bodies and the earth.

UJ’s Food Evolution Research Laboratory (FERL) was established to promote, enhance and encourage research on food evolution to ensure healthier lifestyles and to create a sustainable future. Positioned within UJ’s School of Tourism and Hospitality, FERL focuses on helping people be more cognisant of nutrition, and aware of how their health changes as they move into urban environments, or as they shift from indigenous to Westernised diets.

**How our food choices impact our health.**

A VIRTUAL APPROACH

“The laboratory has been virtual from the start,” explains Dr Hema Kesa, the Director of FERL. “Our intention is to use technology to conduct our research, thereby implementing novel approaches towards South African food science and nutrition research.”

Recently, FERL has been investigating how it can take this further by incorporating 4IR elements into some of its programmes, particularly through the use of extended reality (XR). Dr Herman Myburgh, who recently joined the FERL team, is also exploring the advantages of using virtual and augmented reality (VR and AR).

One programme involves exploring both mal- and overnutrition in different population demographics. We’re trying to understand how people eat in different contexts, and why they make the food choices they do.

~ Dr Kesa, the Director of FERL

Using XR allows the researchers to discover new ways of thinking about our various food environments. “For example, using 360-degree cameras, different food environments can be recorded in four dimensions and later analysed, compared and shared,” Dr Myburgh explains. “What’s more, adjusting the height of the camera changes the viewer’s frame of reference, and allows a supermarket to be viewed from the perspective of a child, for instance.” This approach to data collection delivers useful and meaningful results.
THE IMPACT OF OUR DECISIONS

Some sources cite that the average person makes roughly 35,000 decisions per day. Most of these are made in a split second, and by understanding more of this decision-making process, we can start to alter human behaviour and nudge people towards making more sustainable choices. Using VR, the researchers at FERL are aiming to create a standardised research environment, capable of recording minute interactions between research participants and the virtual environment. "This creates an exciting new avenue for research that focuses on how people make their nutritional choices during the purchasing process," Dr Kesa says.

Although several of FERL’s projects were meant to start in mid-2020, they had to be put on hold due to the Covid-19 pandemic. But that hasn’t slowed Dr Kesa and Dr Myburgh’s enthusiasm. When the time is right, they’re hoping to further integrate XR, VR and AR into their work.

Global health facts and figures.

THE FOLLOWING FACTS AND FIGURES OFFER A GLIMPSE OF THE STATE OF OUR HEALTH GLOBALLY:

One in every nine people in the world is hungry or undernourished.

The growth of almost a quarter of all children under the age of five is stunted.

Undernourished people, who have weaker immune systems, are likely to be more severely affected by Covid-19.

The vast majority of people around the world cannot access or afford a healthy diet.

One in every three people is overweight or obese.

Rates of obesity are 5x higher in the world’s richest countries.

Someone dies every 0:08 secs from diabetes or its complications.

*Source: 2020 Global Nutrition Report
Creating a circular economy of waste.

There’s little doubt that 4IR is bringing massive benefits to the planet. It is in the process of improving industrial processes, mitigating our impact on the environment, and enhancing our quality of life. But in order for the technology that forms part of 4IR to be beneficial in the long term, it has to be sustainable too.

4IR depends on and promotes the use of numerous technological devices. The smartphone industry, for example, compels customers to upgrade their devices every two years or so. But what happens to the older devices once they’ve been discarded? Every year, the world produces approximately 50 million tonnes of waste in electrical and electronic equipment, or e-waste. This waste weighs more than all of the commercial aeroplanes ever produced, and only 20% of it is formally recycled.

If 4IR is truly going to be part of the solution to our global environmental, economic and social challenges, rather than part of the problem, it needs to be positioning itself within a circular economy of waste.

WHAT IS A CIRCULAR ECONOMY?

“A circular economy is an economic system that tries to eliminate biological and technical waste,” says Katharina Gihring, project manager at UJ’s Process Energy and Environmental Technology Station (PEETS). “It involves re-evaluating how we design our products, and how we understand the ownership models of these products. Do we need to own everything we need? Or could we lease them instead?”

Recycling – an age-old buzzword – is no longer the way to go. We need to prolong the lifecycles of products that are still fit for use by maintaining, reusing, redistributing and refurbishing them and, only as a last resort, dismantling them to extract valuable materials that can be redirected into the system.

CREATING CO-WORKING SPACES

“One of the main challenges of creating a circular economy comes in making it socially right,” explains Katharina. “We need to develop systems where people can still gain employment and economic security, while helping to deal with waste in a way that is both ethically and environmentally sound.”

South Africa has an emerging informal sector working in e-waste, but these reclaimers have to sell the waste they source to a middleman, which reduces their earning potential. Complying with legislation is also a major problem. “PEETS has therefore applied for funding to create co-working spaces that will give the informal sector access to the equipment they need in an environment that operates in line with formal sector legislation,” says Katharina.

The co-working spaces grant entrepreneurs the opportunity to rent out an area to dismantle and even partly process the metals they are interested in selling. “In South Africa, our aim is to direct e-waste streams towards these entrepreneurs,” she says. PEETS is working with the Southern African E-Waste Alliance, EMPA at ETH Zurich and the World Resources Forum to make this a reality.

Creating a sustainable world is a complex and multifaceted endeavour. In the 4IR era, it involves being aware of the entire lifecycle of the technology on which we depend, while being aware of the ways in which it can improve people’s lives both economically and socially.
Four questions answered about smart cities.

Maybe you’ve heard the term floating around, but haven’t really paid it much attention. Perhaps the words “smart city” sound like something from a distant future, unrelated to our present-day reality. If this is you: think again. Smart cities are here, and they’re gaining traction the world over for their innovative and sustainable approaches to dealing with the challenges of contemporary life.

WHAT IS A SMART CITY?
A smart city is an urban environment that uses information and communication technology, and the Internet of Things, to run the resources and assets that the city needs. It collects data from citizens to monitor and manage infrastructure such as traffic and transport, energy and water supply, and waste disposal, as well as schools, hospitals and other community services.

WHAT ARE THE BENEFITS OF SMART CITIES?
Smart cities are also called eco-cities or sustainable cities. They’re fundamentally about reducing our environmental impact on the planet by reducing CO₂ emissions through a number of measures, including using clean and efficient transportation methods for people and goods. Smart cities are also designed to optimise various services and to keep people safe.

WHAT ARE SOME EXAMPLES OF SMART CITIES?
Singapore, San Francisco and Oslo are all examples of smart cities. While Singapore has road sensors, phased traffic lights and smart parking, San Francisco uses 100% renewable energy for all its municipal services. Oslo has equipped thousands of streetlights with sensors so that they can adjust their brightness depending on the season.

DOES SOUTH AFRICA HAVE ANY PLANS TO CREATE SMART CITIES?
In February this year, President Ramaphosa announced plans to develop a new smart city in Lanseria, just outside Johannesburg. The development will be home to between 350,000 and 500,000 people within a decade, he said, and will be smart, 5G-ready, and a leading benchmark for green infrastructure on the continent and in the world.
Young industrial designers usher in new era of environmental awareness.

Industrial designers are trained to use large industrial applications to execute their work. These processes are essential to create the millions of products we use every day, products such as chairs, lamps, fridges and mobile phones. But the techniques involved in these processes are often energy intensive and have serious environmental impacts. If this industry, which is so critical to our lives, is to mitigate against rather than contribute to environmental degradation, it needs to adapt.

This, UJ’s Department of Industrial Design argues, has to have its foundations in designers’ educations. “Industrial designers need to understand the implications of the materials they use in their products,” says Martin Bolton, a senior lecturer in the department. “In order to equip students to be more conscious about these materials and their environmental impacts, the Department of Industrial Design has incorporated experimental material development into its curriculum.”

Third-year students are tasked with developing their own material composites, which are then used to create a product. Recent products included the heating and moulding of seeds, sugar and beeswax to create a biodegradable side table, and the use of compressed coal, gelatine and woven grass to design a watch.

“By processing their own materials and creating an environmentally sustainable product, young designers become more aware of how their work interacts with the natural world,” explains Martin.

“This consciousness and transparency is empowering – both for the designers, and the end users who choose their products.” – Martin Bolton, senior lecturer in the Department of Industrial Design.
Mobile water lab improves the health of remote communities.

Access to good quality water, sanitation and domestic hygiene is a cornerstone of public health. Without it, people run the risk of contracting a variety of dangerous waterborne diseases, some of which can be fatal.

In remote areas where access to water is problematic, or in the wake of natural disasters that cause water supplies to become contaminated, it is necessary to test water before it can be used. But the laboratories that undertake this sort of analysis are usually located in big cities, often far from areas in need of help. And while field labs are an option, they can be time consuming to set up, and are often hindered by difficult conditions on site.

FULLY EQUIPPED AND OFF-GRID

That’s why Professor Tobias Barnard, Director of the Water and Health Research Centre at UJ, research coordinator Dr Kousar Hoorzook and industrial designer Robin Robertson designed and built a mobile water lab.

The lab can operate off-grid, has high road clearance and can be towed by a 4x4. It runs its sample fridge, incubator, analysis equipment and air-conditioning on solar panels, a generator and batteries, and carries its own safe water supply. It also has a side tent to accommodate more testing equipment and, if necessary, provide shelter for staff.

“The space inside was set up so you can bring in different types of equipment to do different types of analysis,” says Professor Barnard. “If you find that you’ve got to test for typhoid, dysentery or cholera, you can easily adapt your setup on site and test for it.

THE RIPPLE EFFECT OF CARE

The lab is a cost-effective way of monitoring water treatment plants, community water supplies, schools, clinics, and hospitals for potential water, sanitation and health problems. Regular monitoring helps to ensure that fewer children miss school due to diarrhoea, fewer employees take sick leave, and fewer people arrive at hospitals and clinics with preventable problems.

The team at the Water and Health Research Centre has also established BlUJoy, which uses social media to share, educate and inspire the public to use water responsibly and to respect it. In early 2020, as the world came to grip with Covid-19, BlUJoy’s YouTube channel shared important information on making water dispensers for handwashing, which is critical in helping to stem the spread of the virus.

Between the mobile lab and BlUJoy, UJ’s Water and Health Research Centre is helping to ensure that clean and safe water is a priority and a reality for everyone.

Click here to learn more on BlUJoy’s Youtube page.
A playful and innovative approach to future-focused design.

In 2020, UJ’s Department of Industrial Design gave its second-year students a project: they were instructed to design an artefact that solved a problem through imaginative means that may not currently be possible. This speculative design project aimed “to open up new perspectives on problems, to create spaces for discussion and debate about alternative ways of being, and to inspire and encourage people’s imaginations to flow freely.”

Using the Afrofuturism of the superhero film Black Panther for inspiration, industrial design student Sophonia Mosethe created a product called Cyber-Trace. This glove-like device set out to solve a variety of problems related to food security, including seed and soil quality that has been degraded by climate change, droughts and poor farming methods. “Cyber-Trace helps farmers grow more crops at a faster rate,” Sophonia’s report explains, “so helping to save lives and the planet at the same time.”

The boundless thinking of this project helps students to imagine what problems the future may hold (the challenges of food security, Sophonia predicts, aren’t going anywhere), and how best to address these issues. In the process, it teaches innovation to the next generation of industrial designers and scientists – a critical tool in the 4IR arsenal.
The Future. Reimagined.