Science Business Society Dialogue Conference

Strengthening the Science Business Society Dialogue in the SADC Region

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The Academy of Science of South Africa (ASSAf) was inaugurated in May 1996. It was formed in response to the need for an Academy of Science consonant with the dawn of democracy in South Africa: activist in its mission of using science and scholarship for the benefit of society, with a mandate encompassing all scholarly disciplines that use an open-minded and evidence-based approach to build knowledge. ASSAf thus adopted in its name the term 'science' in the singular as reflecting a common way of enquiring rather than an aggregation of different disciplines. Its Members are elected on the basis of a combination of two principal criteria, academic excellence and significant contributions to society.

The Parliament of South Africa passed the Academy of Science of South Africa Act (Act 67 of 2001), which came into force on 15 May 2002. This made ASSAf the only academy of science in South Africa officially recognised by government and representing the country in the international community of science academies and elsewhere.

This report reflects the proceedings of the Science Business Society Dialogue Conference held on 6-7 December 2016 at the CSIR International Convention Centre, Pretoria, South Africa. Views expressed are those of the individuals and not necessarily those of the Academy nor a consensus view of the Academy based on an in-depth evidence-based study.

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SESSION ONE: OPENING – Facilitator: Prof Dr Volker ter Meulen, Immediate Past-President, German National Academy of Sciences, Leopoldina

Prof ter Meulen welcomed all participants to the conference and extended a special welcome to His Excellency Mr Walter Lindner, the German Ambassador to South Africa; the Executive Officer of the Academy of Science of South Africa (ASSAf), Prof Roseanne Diab; the Vice-President of ASSAf, Prof Barney Pityana; and Mr Fanana Dlamini, Principal Secretary of the Ministry of Information, Communication and Technology in the Government of the Kingdom of Swaziland and representative of the Southern African Development Community (SADC) region.

Science and business need to develop a better understanding of each other. Science discoveries benefit all societies and businesses, and therefore communication between science and business is vital for all society. Science in society must become more acceptable in order to strengthen science for the benefit of society. Scientists need to be responsive to the changing needs and concerns of society. Society, in turn, needs to understand and support the positive role of science.

OPENING AND WELCOME REMARKS – Prof Barney Pityana, Vice-President, Academy of Science of South Africa (ASSAf), Secretary-General: Network of African Science Academies (NASAC)

It is an honour for me to be here this morning to address this conference on behalf of the President of NASAC, Prof Mostapha Bousmina of Morocco, who is unable to honour your kind invitation for personal reasons. He has entrusted me with this task and I am proud to stand here to acknowledge this initiative that brings science and business, scholarship and practitioners, Africa and Europe together to engage in one of the critical levers necessary for human flourishing in our world.

Let me first acknowledge those among us who have made this possible: Prof Volker ter Meulen, Immediate Past-President of the German Academy of Sciences Leopoldina, and Prof Prof Jutta Schnitzer-Ungefug, Secretary-General of Leopoldina. From ASSAf, Prof Himla Soodyall, General Secretary of ASSAf; Prof Stephanie Burton, ASSAf Council member; Prof Roseanne Diab, Executive Officer of ASSAf; and the staff from the ASSAf office. I also wish to acknowledge His Excellency Mr Lindner, the German Ambassador in Pretoria, and Mr Fanana Dlamini, Principal Secretary of the Ministry of Information, Communication and Technology in the Government of the Kingdom of Swaziland, as well representatives of the Department of Science and Technology of South Africa and participants.

Distinguished guests, ladies and gentlemen, it is a great pleasure to speak at this conference. I understand that this is the first conference of its kind hosted by ASSAf in collaboration with Leopoldina, the Department of Science and Technology (DST), the Network of African Science Academies (NASAC), the European Academies' Science Advisory Council (EASAC), the Southern African Development Community (SADC) and the Global Young Academy (GYA). I am pleased to see that this conference is attended by participants from all SADC countries, as well as Kenya, Germany, Austria and the United Kingdom. The participants come from diverse backgrounds representing business, policymakers, scientists and civil society.

As I begin to speak, I believe that it is worthy of us to pause and share with Prof Wieland Gevers and his family as they mourn the death of his wife, Mrs Lizzie Gevers, who passed away yesterday. Prof Gevers can justly be honoured as the founder of ASSAf, a former President and Immediate-Past Member of Council. He continues to be a great inspiration for the work of ASSAf. So may I ask that we rise for a moment's silence today to honour Mrs Gevers and share in the grief of the family (one minute silence). Thank you.

I have been asked to briefly speak on the role of academies in strengthening the science business dialogue on the African continent. It is important to place the role of academies within broader contexts, both global and national. In the context of the SADC Industrialisation Strategy and Roadmap 2015 to

2063, it is worth noting that the theme of the conference is "Strengthening the Science Business Society Dialogue in the SADC Region". The SADC Strategy is aligned to national, regional, continental and international dimensions. Its primary focus is the technological and economic transformation of the SADC region through industrialisation, science and technology, financial support and stronger regional integration. The strategy seeks to encourage institutions of higher learning to foster linkages with business and industrial communities. The document indicates the importance of establishing a platform for public-private dialogue on industrial policy and its implementation. The objectives of the strategy will not be achieved without concerted efforts from scientists, business, policymakers, as well as civil society. There is a critical need to involve the young and, in particular women, in programmes and initiatives focused on research, entrepreneurship and policymaking.

Beyond the SADC region, you are no doubt aware that there is no shortage of plans, strategies and policies in Africa. There is no deficit in the desire to frame public policy around achievable goals and outcomes. It is also true that Africa has no shortage of skills, knowledge, and intelligence in human, natural and scientific resources. Take a look at the journey of the United Nations (UN) from the Millennium Development Goals to the Sustainable Development Goals adopted by the General Assembly in September 2015: zero hunger, good health and well-being, clean water and sanitation, affordable and clean energy, industry and innovation, climate, oceanic and maritime life. They all speak to the contribution of science to human development.

The African Union (AU) Agenda 2063 is billed as Africa's initiative to "optimise the use of Africa's resources for the benefit of all Africans". Speaking as it does to the Africa we want, the AU vision is a challenge to science and business in Africa. Recently the AU charged His Excellency Mr Paul Kagame, President of Rwanda, with the task of leading a team to review the effectiveness and achievements of the AU. In the initial team of nine experts there was no recognisable scientist. The President of NASAC was moved to write and to offer names of African scientists that President Kagame could call upon to advance the work that had been entrusted to him. Science is a necessary component of development.

Academies of science play a pivotal role in providing a platform for science, business and society dialogue for two reasons. First, academies are in a unique position to bring together government, industry and civil society in order to bridge the gap between science and business. Second, academies serve as a voice for science by making the best available information accessible to all stakeholders. Many of the major manufacturing industries have invested hugely in in-house research and development (R&D) units in order to ensure innovation and source new ideas and improve on their products. Alongside that is the academy that is uniquely established to be the repository of fresh and new ideas, independent evidence-based research, and intellectual capital that is an accumulation of knowledge and a critical voice on the possibilities of science for human development. Yes, arguably, these two vital sectors of human development may not naturally cohabit and tend to view each other with suspicion, perhaps even to challenge each other's world views. We need a culture of collaboration and sharing of knowledge and resources that enhances the products of both science and business.

NASAC is a regional network that aspires to be the voice of scientists. NASAC's strength is entrenched at regional and sub-regional levels, making it able to influence regional policy more effectively than its individual member academies. As part of its Strategic Action Agenda, NASAC is committed to:

- Assisting with the establishment of new academies of science across Africa and providing advice and training for their effectiveness and success.
- Building confidence between academies and policymakers.
- Drafting evidence-based policy advice to African governments and institutions.
- Initiating formal linkages with key African institutions such as the African Union, UN Economic Commission for Africa, New Partnership for Africa's Development (NEPAD) and the African Development Bank.

- Organising workshops and conferences on topical issues by exploiting expertise from across the continent.

NASAC and its affiliated academies, including young academies, can play an important role in providing evidence-based scientific advice to solve key challenges on the continent. African academies have a much bigger role in ensuring the development of science, technology and innovation that underpins job creation. It is pleasing to note that the first dialogue on science business society is coordinated by the academies of science. As we deliberate on the challenges and opportunities that exist in the SADC region, I hope that we will be able to come up with solutions on how to bridge the gap between science, business and society.

I wish this conference the very best. I am delighted that academies of science in Africa, as well as those responsible for the advancement of science and technology in African governments, especially in this case the SADC region, as well as business, are all here together to consider how best the challenges that face humanity can at least raise the possibility of resolution.

Dr Anna Coussens, Former Executive Committee Member, Global Young Academy (GYA)

The GYA grew out of discussions amongst top young scientists from around the world convened by the InterAcademy Partnership (IAP) at the Annual Meeting of New Champions of the World Economic Forum in 2008 and 2009. The GYA was officially founded in February 2010 with support by the IAP as the global network of science academies. With the help of the German National Academy of Sciences Leopoldina, the Berlin-Brandenburg Academy of Sciences and Humanities (BBAW) and the German Young Academy, the GYA received start-up funding from the Volkswagen Foundation. Since October 2011, the GYA has had an office hosted by the BBAW in Berlin, Germany. Since 2014, the German Federal Ministry of Education and Research has provided core funding to the GYA for an initial period of three years, and funds for a further four years have just been granted.

The GYA's focus is on science and policy, education and outreach, open science and the research environment. Membership consists of 200 members who are selected for the excellence of their science and their commitment to service and outreach. There are a number of working group projects that drive interaction with science and society. Females comprise one-third of the membership and 50% of the Executive Council, and two females have been elected as co-chair at the last two elections.

Annual general meetings are held on the theme of how the academy can engage science and society to build sustainability and to reduce the science gap between developed and developing countries by connecting young scientists from different countries. Research and innovation is widely recognised as one of the most important engines of economic growth, socio-economic development and enlightenment for countries. Research plays a vital role in a knowledge-driven economy. In recent years, particularly since the 2008 financial crisis affecting the global economy, innovation has become critical for the global economy, despite the increasing complexity of current economic, environmental and social challenges.

Engagement with other international organisations includes collaboration with the IAP, the United Nations Educational, Scientific and Cultural Organisation (UNESCO), the International Council for Science (ICSU), Lindau Nobel Laureates, The World Academy of Sciences (TWAS) and the European Union Joint Research Centre. The goals of GYA are to engage, support, build and promote science education and science-policy integration. The academy's three main themes are:

- Science and society, which concentrates on the contributions of science to questions and challenges of relevance to society, including policy advice on a global level.

- Research environment, which includes working groups and projects dealing with the conditions in which research inside and outside academia works.
- Science education and outreach to inspire and educate people about the value and possibilities of science.

In preparing the next generation of global science, technology and innovation (STI) leaders, the GYA works in different working groups that aim to narrow the gap between the developed and developing world by equipping future leaders with skills training and experience, through leadership and mentoring programmes and by increasing diversity. The GYA supports and facilitates international and interdisciplinary networking, aimed at increasing collaborative innovative research. The visibility of young scientists is broadened by the GYA engagement with decision-making bodies such as granting councils, and advisory, screening and evaluation committees. Young researchers are encouraged to take up societal and environmental challenges through the support of, and engagement with, the national young academies and the GYA at ministerial level. Young scientists are able to share best practices among and beyond member countries by holding global, regional and topical workshops to encourage governments, research foundations and organisations to engage with young researchers.

The Global State of Young Scientists (GloSYS) is a working group within the GYA that aims to identify challenges in the career development and research environment of early career scientists to provide valuable information for decision-makers and policymakers that can be used to benchmark progress towards creating better support networks and research systems that encourage education in the sciences, provide stability for researchers, and create a research system that promotes excellence and impact; all of which is a vital part of innovation and wealth-creation. A number of individual programmes undertaken in different geographical areas determine recommendations to address mentoring and support structures and focused training, improve evaluation processes and working conditions such as reward for commercialisation and intellectual property (IP). A study in the South-East Asian region found that the leading drivers for young people to enter science were that they wanted to create innovative products, apply knowledge to benefit society and teach the younger generation. Whilst remuneration and society's respect for science were the least influential, suggesting that young scientists are attracted to a career in science to progress society, despite society not placing a high value on the work that they do.

In a pilot study of the GloSYS project that dealt with African early-career researchers, the identified challenges were the lack of adequate job opportunities beyond academia, funding for research, seed monies and career knowledge. Science and innovation are interlinked, but the skills of innovation and space to innovate are limited. Academia and business need to be encouraged to interact with science. Scientists need to be taught to engage early and to understand how business and society work, which will enable scientists to innovate appropriately in order to drive African science forward.

His Excellency Mr Walter Lindner, German Ambassador to South Africa

Mr Lindner noted that conferences of this nature bring together the connective voices of science, technology, innovation, economy, business and policies. There are perceptions that scientists undertake their research studies in a closed environment and that it is difficult to transfer their findings and outcomes to the real world. Scientific language is not understood in the real world unless the research is turned into something concrete that the business world and society can understand.

South Africa is a strategic partner with Germany on the African continent. Over 600 German businesses are active in the country and have created approximately 100 000 jobs. Exchange at political level is strong on topics ranging from science to renewable energy. It is essential for businesses to combine technology and innovation and science. The mechanisation of processes is technically elegant and aesthetically pleasing, yet also has the potential to be socially destabilising. For example, the BMW plant in Rosslyn, Pretoria previously employed 900 workers, but today the plant has 40 employees who control

the computers and robots. This increase in commercial productivity has given rise to unemployment and poverty. Politicians need to provide frameworks to deal with the ramifications of new technologies in the workplace, as well as the consequences of unemployment.

The combination of the world's population explosion, global warming and the lack of natural resources provides 'the perfect storm'. It is predicted that a global population of eight or nine billion would place planet Earth under too much pressure. Currently the world's population is estimated to be 7.3 billion and is predicted to rise to 12 billion by the end of the century. In terms of global warming, the international community has committed itself to not raising the temperature of the planet by more than 2°C by the end of this century, but 2°C is too high as this will lead to a decrease in agricultural areas, more deserts and less food.

Natural resources are required for technology, but these will gradually become depleted within the next few centuries. This provides a gloomy scenario for the survival of humanity, including food security. The world is already facing challenges in feeding its population. If the population were to double, it will no longer be possible to feed everyone. Scientists need to come up with new technologies in areas such as harvesting, fertilisers, food sciences, water treatments for drinkable water and transport.

It is estimated that there will be 27 megacities in the world by 2025. Unless measures are taken soon, these megacities will pose significant threats in the coming decades. What happens in the megacities of the developing world affects the rest of the world. Megacity problems are generally exacerbated by serious deficits in the realm of knowledge. These are deficits in the generation of knowledge, such as the research necessary to address the problems of the megacity, and in the dissemination of knowledge, for example in education systems. There are also deficits in the utilisation of knowledge by the relatively poor and uneducated populations of megacities. Megacities need to address the generation, diffusion, and utilisation of knowledge through research and education.

The combination of high population density, poverty and limited resources makes the developing world megacity an environment that favours the incubation of disease, which in an age of rapid communication can almost instantaneously be propagated to the rest of the world. Digital and IT revolutions have a devastating impact on employment. Science must find alternative solutions for the developing world that is different from those of the developed world. Standards and specifications should favour low-cost technologies that require little maintenance and are easy to repair, instead of advanced high-performance technologies.

The world is running out of time. Responsible business people, scientists and politicians need to move urgently. There is a pervasive and crucial need for policies and socio-technological and socio-economic approaches to be devised to address different settings, needs, challenges and opportunities. Governments and businesses, both in the public and private sectors, need to commit the necessary funding for science councils and institutions to undertake research. Innovation is increasingly crucial for economic and social development. The GYA and other young science academies are essential actors in finding solutions. They must realise that there is a sense of urgency to come together to take action to ensure that economic, social and technological progress occurs in harmony with the desired development of the region.

Setting the Scene: Introduction – Prof Roseanne Diab, Executive Officer, ASSAf

The title Science Business Society Dialogue was carefully chosen as it reflects ASSAf's conscious desire to create an opportunity for conversation between the three. A special effort was made to bring in youth and gender perspectives in the hope that the participants from the three groups would be challenged by the dialogues from the youth so that new partnerships could be formed, existing partnerships could be strengthened and due considerations would be given to their views.

SADC is part of the African continent and also part of the global community. There is much to learn from the African regions, and opportunities have been provided for the sharing of experiences from many countries around the world.

The science business society nexus and its role in the national system of innovation could be likened to a marriage. Both the national system of innovation and a marriage are complex and non-tangible. Each consists of partners, each with their own identity and capable of functioning independently. They also form part of a bigger structure that requires them to acknowledge the needs and aspirations of the other party in the relationship to work towards a common goal. However, the parties are different; they have different priorities, different ways of operating and sometimes do not speak the same language. In diversity there is strength; whether it is a couple in a marriage or science and business in the national system of innovation. When this structure functions well, it is a formidable team. Relationships are fragile, however, and need to be continually nurtured or they will fail. If they break down, it is possible for partners to co-exist or even to cohabit and for each to continue with their own separate lives, but something would have been lost in the process. In many countries it is true to say that this marriage, or the national system of innovation, is not a glorious bed of roses. The relationship often struggles; it experiences many problems and does not measure up to expectations. In seeking solutions to overcome these problems, the key would be to open up the channels of communication and for the partners to listen to and to hear one another. This conference provides the ideal platform for dialogue among the parties and for representatives of the various players in the national system of innovation to open up channels of communication so as to better understand one another and forge stronger partnerships.

Prof Diab expressed the hope that deep and meaningful engagements, new partnerships and friends would be realised through the conference. She thanked the sponsors of the conference – the German Federal Ministry of Education and Research, the DST in South Africa, Leopoldina and ASSAf – and hoped that this initiative would bear fruit and open up new partnerships.

Science, Business and Society in the SADC Region: An overview – Prof Francis Petersen, Deputy Vice-Chancellor, University of Cape Town (UCT)

Science, research and innovation are the fundamental key drivers towards economic growth, global competitiveness and social upliftment for a better life for all. This highlights the importance of investment in science and innovation. In order to create an enabling environment for an active conversation between science, business and society in the SADC region, there must be a collaborative effort in order to better understand the needs of the three actors. A collaborative value proposition would need to form part of the dialogue so that each partner would benefit from the partnership.

Dialogue should include high-end skills development. Whilst high-end skills are often produced at Masters and PhD levels, the question that should be asked is whether the science that is being produced is internationally recognised. Science forms the fundamental platform for innovation and the transfer of technology to benefit both business and society. The conversation should also look at technologically driven research output. Dialogue should encompass inclusive innovation that addresses the needs of all business and society, irrespective of their monetary wealth.

The size of international companies operating in countries around the world appears to have downscaled. In South Africa whilst there are many international companies operating out of its confines, the economic growth is mainly driven by small and medium enterprises (SMEs). Therefore entrepreneurship should be included in conversations between science, business, society and government.

Funding will always form part of dialogue. Funding should ensure that funds are appropriately applied to the uses for which the funds were approved. Mechanisms should be in place for the financial control and accounting of funds. Furthermore the inter-SADC migration of skills to build the region with multiple

skills would require greater levels of cooperation and integration and the understanding of the needs of both business and society in the region.

In the SADC region, the percentage of the gross domestic product (GDP) spent on R&D amounts to only 1% of GDP. This is not sufficient for the security of the region; the percentage should be in the region of 1.5% of GDP. Furthermore the spread of R&D expenditure between government, business and public research would need to be addressed. The ratio between national and international investment in R&D should be carefully analysed in SADC countries. Whilst the region needs investment from international partners, countries should avoid over-reliance on international investment.

Investment in high-end skills can only be achieved with a good education base. Investment in education remains a critical element of the solution to create more skilled workforces within the SADC member states. Participation in tertiary education across the region is very low and this would need to be the subject of dialogue in order for the region to produce an adequate human resource base.

The balance between the humanities and social science, and engineering and natural sciences in the SADC region is not at the level where it should be, and the trend towards engineering and natural sciences needs to be increased. The human and social sciences can also make a meaningful contribution. Universities across the SADC region are not always appropriately equipped to produce high-level skills and good science. Levels of staff, physical infrastructure and appropriate funding remain challenges for most universities and learning institutions. Business should start developing a closer link with universities and research institutions.

Although not directly linked to science, the lack of focus on vocational education and training in the SADC region is an area for concern as these are vital for producing the necessary skills for improving economic performance, alleviating poverty and reducing unemployment.

Appropriate mechanisms for the transfer of technology for the effective uptake of research by business and society is lacking in the region. Most South African universities have technology transfer offices that create platforms for engagement between business and society; such offices should be implemented across the SADC region. The government of Finland is looking at building stronger technology transfer capacity at universities in southern Africa.

Business and society in the SADC region are more closely aligned to research providers than to each other. Industry and businesses need interdisciplinary research approaches to societal challenges such as energy, climate change, food and water supply, which are key factors related to new markets for products and services. Research providers are the main source of new knowledge, innovative thinking and skills development on societal needs. Aligning interests and sharing experiences should be encouraged between science, business and society.

SADC's intra-regional trade remains low compared to its extra-regional trade. The Green Paper on International Migration should be scrutinised to see how the migration of skilled labour can be managed proactively and strategically in order to contribute to the spread of skills within the region and to build improved human resources capacity.

Innovation is increasingly recognised as an important tool for driving structural change, strengthening competitiveness and finding solutions for tackling societal challenges in the SADC region. There has been a decline in business investment in R&D, and the challenge is to focus on doing more with less and finding new opportunities for innovation. African countries are able to collaborate with many countries in order to have access to good science. Science must be globally competitive and must build competency and capacity.

Publications, patents, artefacts, exhibitions and other forms of research output are important in the pursuit of the intellectual and academic agenda; however, the question of how these outputs can change

the way in which business and society function is critical. Science, technology and innovation policies cannot compensate for poor governance and framework conditions. Without properly laid-out policies that result in action to include the participation of more people in economic activity, poverty in the SADC region will never be reduced.

Discussion

Prof ter Meulen (Leopoldina) commented with regard to IP in science that businesses and industry were often interested in the findings and achievements of research and in taking that research further. This poses problems in the structuring of funding and in determining the ultimate holder of the IP and needs to be managed.

Prof Petersen (University of Cape Town) responded that universities, science councils and research institutions are public institutions. In South Africa, the universities fall under the Department of Higher Education and Training, while science councils such as the Council for Scientific and Industrial Research (CSIR) and the National Research Foundation (NRF) fall under the Department of Science and Technology (DST.) The Intellectual Property from Publicly Financed Research and Development Act (2008) deals with IP where public funding is involved. A business partner that wants to do research or product development at an institution would need to provide funding according to one of several models. Should funding be given at full cost, the partner would be in a position to negotiate for ownership of the IP. Should full funding not be provided, the IP would remain with the science council. Universities also offer various funding models to incentivise researchers.

A question was posed about what could be done in the SADC region to overcome the challenges outlined in Mr Petersen's presentation.

Prof Petersen (University of Cape Town) responded that multiple approaches would be required to tackle the challenges. Government would need to enable policies and make a large contribution to investment in R&D, but different governments in the region would respond differently. They would need to determine how and where the funding would be directed and to measure the return on that investment. The skills and competency profile of academic and research staff at universities in the SADC region are not evenly distributed. There should be greater collaboration between institutions themselves and research providers to drive the mobility of skills in the higher education sector. Businesses could also play a role, especially where they have offices and operations in more than one SADC country. They should investigate the possibility of mobilising staff between their international offices. Social innovation is required in order to mobilise society. Government development agencies should also talk to the social investment arms of companies. This would require the intervention of ambassadors or catalysts from government, business and universities.

Mr Ndzendze (Eskom) disagreed with the statement that there was little relationship between business and society. When businesses are developing a product they know where it will go, and society can influence this. Business seeks a return on its investment, and business R&D expenditure is declining. Is this because people are not innovative enough to come up with new ideas that can improve their businesses? In the SADC region, the bio-fuel programme is associated with the use of grains such as maize, soya and sunflower and impacts on the stability of food supply. These plants need a lot of water to produce, and drought has a serious impact on their production. How can business and society strike a balance in solving this?

Prof Petersen (University of Cape Town) responded that the relationship between business and research providers is much stronger than between business and society, and that the latter needs to be strengthened. There are several reasons for the decline in business R&D expenditure. If a business is suffering financial constraints, one of the first expenditures that would be reduced or cut would be the R&D

budget. Many businesses look to other countries to get value and returns for their goods. While they may be spending on R&D, the expenditure may not necessarily be in the SADC region. This will affect the percentage of GDP allocated to R&D in the SADC region. Regarding bio-fuels, there has been a drive towards wealth creation and economic growth as opposed to food security. In South Africa, environmentalists are exerting pressure against nuclear power, but electricity is needed to supply the entire population. Conversation between science and business would assist government to balance the needs of business and society so that a decision could be made for the benefit of all.

Ms Shaba (Tanzania Association of Non-Governmental Organisations) commented that the way in which business and society function must change. She asked how this could be addressed in a neo-liberal environment.

Prof Petersen (University of Cape Town) responded that conversations should respect fundamental rights and environmental issues. Governments need to take a liberal approach and provide at least the framework for dialogue. They should also take responsibility for providing business with a roadmap or legislation in order to empower members of society for meaningful engagement.

Mr Mafa (BioSafety Board of Zimbabwe) commented that investment in high-end skills and research in Africa is not new. Universities are producing very little new cutting-edge technology and appear to be 'mass producing' PhDs of little value. He queried how this challenge could be addressed in Africa. There has been a shift from the natural sciences and engineering to the humanities and social sciences as the latter are more creative, and it is no longer attractive to be a scientist in the natural sciences.

Prof Petersen (University of Cape Town) responded that the quality of qualifications and the quality of the science produced through those qualifications is a concern. International peer reviews should be the benchmark to ensure quality. Universities in the region should collaborate to help build stronger qualifications and to have a better spread of good quality staff. In South African, there is often 'mission creep' between institutions and between universities. Some universities make technology programmes available to students in areas where there has been no previous provision. Students who do not meet the requirements for university degree study are often offered shorter, work-related qualifications with the possibility of further advancement. There is a need for dialogue between academic and learning orientations for mutual enrichment and to meet the complex demands of developing economies. Governments and policymakers around the world are increasingly recognising the critical relationship between education and socio-economic development. In the diversity of their academic offerings, the flexibility of their structures and the opportunities they offer to students, learning institutions should position themselves to make significant contributions to development at local, regional and national levels.

Mr Hlahane (Blue-Green Aquaculture) commented that in 2008 and 2009, the University of Cape Town (UCT) initiated the Postgraduate Diploma in Entrepreneurship (Genesis Programme), which provided graduates with an intensive one-year introduction to the theory and practice of entrepreneurship. One of the university's spinoff companies, Cape Carotene, was involved in scaling up an algal process to commercial production capacity to produce astaxanthin. Science graduates were generally not aware of the programme, as it was orientated towards the commerce faculty rather than the science faculty. Another challenge is to access seed funding for technology transfer. Mr Hlahane asked whether the companies that emanated from the Genesis Programme could be rejuvenated in order to give people outside UCT access to that technology transfer and funding.

Prof Petersen (University of Cape Town) responded that UCT offers various postgraduate diplomas in entrepreneurship and marketing and that from 2017 would be adding a new specialisation in business communication. Students with undergraduate degrees in, amongst others, science, humanities, engineering, medicine and architecture, have found that these diplomas have added significantly to their education. UCT's Graduate School of Business has specialist centres such as the Bertha Centre for

Social Innovation and Entrepreneurship, the Allan Gray Centre for Values-based Leadership, and the Solution Space which is an innovation hub at the heart of its campus. One of the many projects includes the Philippi village development, which aims to nurture entrepreneurs and support skills development and job creation. The university also has a student society on entrepreneurship, which attracts not only commerce students but also science students. This affords students the opportunity to obtain a degree in their chosen fields and to further their knowledge of business. The university also has a technology transfer office. Furthermore, UCT has developed an extensive innovation policy not only for technology-driven innovation, but also for innovation in teaching and learning across the disciplines.

Dr Bamwenda (Tanzania Academy of Sciences) observed that over the past 30 years, Tanzania had experienced a mismatch between humanities and social sciences, and engineering and natural sciences and that almost all leaders in government were from the humanities and social sciences. With the industrialisation of Tanzania, the lack of skilled engineers and technicians had emerged to such an extent that the government was now giving preferential treatment for science and engineering students. Students were given grants for university studies and in some instances even incentives in terms of employment. As a result, Tanzania was seeing increased interest in science and engineering.

Prof Petersen (University of Cape Town) responded that while investment should be made in the humanities and social sciences, the challenge was to get the balance right. UCT established the Hasso Plattner Institute of Design Thinking, which is the only academic institution in the region that offers academic training and capacitation in design thinking to university scholars and professionals in the public and private sectors. Students from all disciplines, industry and government executives come together to learn to work collaboratively in diverse and inclusive multidisciplinary teams on real world challenges and to develop human-centred innovative solutions. The students work in inclusive and diverse transdisciplinary teams and are trained in design thinking, which equips them to develop creative approaches to problem-solving, contribute to the culture of innovation and think laterally when tackling social problems and real-world challenges. The school enrols many masters and doctoral students in the human and social sciences.

Prof Pityana (NASAC) remarked that South Africa has a very diverse system of science, innovation and research institutions, including government-funded research institutions, universities and business, but the country's industrialisation and innovation policy was not making as much progress or producing the innovation impact that countries with lesser resources were achieving. He asked what should be done to address this.

Prof Petersen (University of Cape Town) agreed that the level of industrialisation and innovation in South Africa should be higher considering the level of investment and skills in the country. The DST had done much to address this, including revitalising and updating the Ten-Year Innovation Plan in 2015. The policies that drove South Africa in the past were key inhibitors to the flourishing of innovation. Competition between institutions also inhibits collaboration and needs to be addressed by collaborative conversation. The National Advisory Council on Innovation brings together chief executive officers of science councils and vice-chancellors of universities to ensure that science technology and innovation contribute to achieving South Africa's national objectives.

SESSION TWO: STAKEHOLDER INVOLVEMENT AND BUSINESS INITIATIVES – Facilitator: Prof Voster Muchenje, Research Professor, University of Fort Hare

Early Stakeholder Involvement – Mr Florian Schütz, Senior Research and Innovation Advisor, Fraunhofer Centre for Responsible Research and Innovation (CeRRI), Germany

The Fraunhofer-Society focuses on applied science, technology and engineering. According to the European Commission, responsible research and innovation entails societal actors working together during the whole research and innovation process in order to better align the process and its outcomes with the values, needs and expectations of European society. The Centre for Responsible Research and Innovation develops new approaches and methods that allow research agendas and technology development processes to focus on societal demands from the outset. It is aligned with the EU's Horizon 2020 research and innovation programme.

European countries have developed a science-based approach to assess the safety of new biotechnology products, but stakeholders want to see more careful oversight and monitoring of the processes and products derived from new biotechnology. Many do not believe that science has satisfactorily addressed their concerns on human health or the environment. Consumers all over the world are insisting on the right to know exactly what is in the food they buy and whether it has been genetically modified. They also want to know whether their food is safe. An integrated and participatory innovation culture is required to foster the transformation of 'science in society' to 'science for society and with society'.

International and national funding agencies have underlined the importance of interaction between science and industry and emphasised that partnering at the earliest possible stage of research innovation is crucial. The German High-Technology Strategy reflects the shift in research policy as the key principle for all publicly funded research. The strategy strives to expand Germany's innovation base so that the country can be successful in key technologies and lead markets. That expansion process will require comprehensive dialogue between science, industry, society and policymakers. Only collaboration and participation by all stakeholders will make it possible for curiosity to lead to ideas and for ideas to lead to innovations for competitive and sustainable products and services. Within a participatory framework, new solutions to significant social questions can emerge and find societal acceptance.

SADC has prioritised stakeholder involvement by emphasising the importance of stakeholder participation in the Regional Indicative Strategic Development Plan (RISDP) and in Regional Strategic Action Plans. The implementation of the RISDP must be based on broad participation and consultation in order to engage as many stakeholders as possible, to create ownership for the outputs, and to internalise the principles upon which it is based.

The Quadruple Helix model drives the interaction in knowledge-driven innovation systems between science, industry, government and the public. This model will require that the roles of the various authorities supporting innovation activities will have to be rethought.

Stakeholder involvement in scientific-technical investigations is a key factor in the success of innovation. According to Grunwald (2012: 75), "scientific-technical inventions are not automatically relevant to society. It is not enough to offer inventions; they must address societal needs and requirements".

It is not easy to succeed in innovation, and sometimes innovation technologies fail. Three main challenges face radical innovation:

- Many government policy structures and policies, including R&D and innovation policies, are ill-adapted to tackle complex challenges characterised by interdependencies that have been intensified by globalisation and ICTs, especially big data and social media. Implementing a system

innovation policy requires sophisticated analytical tools and processes in governments to model systemic problems and to design policy responses, including changes to legislation, regulations or standards, or fostering technology platforms and public-private partnerships.

- Business may be hesitant to invest in innovation to explore transition paths if present or future rents are threatened, which may block the transition of large technological systems to more sustainable paths.
- Addressing societal needs to ensure the uptake of new technologies; without addressing societal needs, many 'socially' useful technologies may not be taken up.

Researchers from Fraunhofer CeRRI have worked with partners from African countries. Studies were done with 54 knowledge and technology transfer experts. The results showed that highly technological solutions 'made in Germany' are regarded as generally capable of helping to resolve some of the most pressing problems in Africa, but the adoption of these solutions rarely works as German engineers often fail to understand the African problem that their technologies are required to resolve, coupled with resistance from local organisations in the societies in which these technologies are required to function. Governments are the primary actors in health care and engineering and must be involved at the conceptual stage. Southern African engineers must also be involved in the development of technologies in order to understand and service them. The strategy should therefore seek to co-develop technologies and involve all stakeholders from science, government, industry and society from both Germany and Africa. It was found that scientific and technological research, particularly in transnational collaboration, plays little role in the lives of most people. Research innovation relies on public interest in science and in academic education. The empowerment of people by giving them the opportunity to co-direct scientific technology, particularly in rural areas, is critical for innovation to be welcomed, fostered and successfully transferred.

In order to achieve radical and sustainable innovations, new sources of knowledge and strategic co-operation among all stakeholders must be applied. Innovation research has shown that integrating different stakeholders is challenging. Products and services need to be developed to meet public needs and demands. Other challenges include language and patterns of thought, priorities and values and the 'silo' scenario of operations and research. To overcome these challenges, CeRRI focuses on social science and design research. Methodologies must accommodate public preferences in order to foster the viability of innovations and co-shape long-term trajectories of socio-technological advances.

It is imperative for researchers to identify which stakeholders impede the implementation of innovations in their respective fields of expertise and the national context, and to determine the stages of the innovation processes at which stakeholders should be involved and the ways in which they should be involved.

Business Initiatives for Knowledge Transfer – Ms Kammy Young, Innovation Centre of Expertise Manager, Eskom Holdings

Eskom produces over 95% of South Africa's electricity. It has in excess of 41 000 employees, 30% of whom are engineers and scientists. Eskom has 27 power stations most of which are coal-fired, one nuclear station in the Western Cape, with the others based on open-cycle gas turbines and hydro-electricity. Renewables are being introduced into the grid through independent power producers.

Eskom aims to add value to South Africa by driving sustainable growth and improving the lives of communities where it operates. Examples of Eskom's outreach and awareness programmes include:

- The Eskom Expo for Young Scientists International Science Fair is one of the largest science expos in the world and identifies young scientists with potential to encourage them to pursue careers in science, technology, engineering, mathematics and innovation (STEMI). By actively encouraging

the youth of South Africa to pursue STEMI careers, Eskom aims to address the country's shortage of skills in science. The Eskom Development Foundation invests over R20 million per annum to reach out to school learners across the country to give them an opportunity to exhibit their own scientific investigations and engineering projects. The Expo comprises 25 categories and is held in nine regions. It brings together learners, teachers, professional organisations, educational bodies and governments from all over the world and provides a platform for the development of young scientists who are able to identify a problem, analyse information, find solutions and communicate their findings effectively. By participating in the Eskom Expo, learners increase their awareness of science and engineering, add to their knowledge and explore entrepreneurial possibilities while broadening their scientific horizons. Projects with potential may be commercialised.

- The Eskom Power Series is a collection of reference books on technical information based on practical experience in coal-fired power utilities compiled by local and international specialists and subject matter experts. The series was conceived in response to the continuing loss of critical technical skills and experience in the country, and to provide engineers, technologists and technicians of the future with the wisdom and experience of specialists and consultants who have been working within the power utility environment for many years. The programme ensures that the series is updated with the most current information and expertise available. The aim of the series is to ensure that valuable knowledge and experience is captured and transferred for sustained growth and development. The reference series has been donated to all South African universities. The series includes books on mentoring and coaching, water, and the high voltage direct current (HVDC) power transmission. The HVDC book is the only one of its kind in the world and has been translated into Mandarin, French and German for use in other countries. The books are sold across the globe and are exported to 32 countries.
- IP management: Eskom holds in excess of 35 patents in South Africa and other countries. Without using its internal expertise, Eskom is able to exploit IP through various other means. The world's first corona camera and multi-spectral camera, for example, was developed between Eskom and the CSIR and is manufactured by UViRCO Technologies in Pretoria. The camera is able to detect the escape of electricity from power lines, and has many other applications not only in South Africa but around the globe. Companies such as Samsung use the camera to detect and rectify the corona during the manufacture of appliances such as mobile phones, television sets and washing machines.
- The Eskom Business Innovation Competition: Entrepreneurship is a vehicle for job creation and can drive economic growth and development. The competition gives small and medium black-owned enterprises the capacity to enable them to develop, grow and compete in the formal economy. The businesses that enter compete for a share of R1.7 million in prizes and are assessed on their business acumen, track record and potential for job creation.

Discussion

Mr Maema (Technology Innovation Agency (TIA)) enquired whether the Eskom Power Series publications were sold as part of the organisation's IP management programme or whether this was a corporate social investment (CSI) initiative.

Ms Young (Eskom Holdings) responded that the publications are sold in order to supplement the research budget to create more books. There are currently 12 books, and more are being researched, including books on load shedding and IP in order to show scientists and engineers what is happening in the organisation. The production of the Eskom Power Series is therefore a combination of both IP management and CSI.

Dr Gabriel (National Technological Centre, Angola) asked what model the CeRRI uses to address the IP protection of products belonging to different stakeholders.

Mr Schütz (CeRRI) responded that CeRRI uses ideas for innovation that emanate from society. If these are deemed viable to be developed into products, stakeholders are invited to participate in researching those ideas. CeRRI undertakes the research for industry but is prohibited from the development and sale of products. Cooperation with industry is vital and also results in the building of IP.

Prof Muchenje (University of Fort Hare) commented that ethics remains a serious challenge between science and business. He asked how Eskom and CeRRI address this issue.

Ms Young (Eskom Holdings) responded that Eskom complies with the code of ethics of the International Organisation for Standardisation, i.e. ISO.

Mr Schütz (CeRRI) responded that CeRRI is responsible for research and innovation and that ethics needs to be developed to drive innovation based on societal needs.

There was a question on how Eskom manages the IP of projects emanating from industry, whether national or international.

The comment was made that companies often compete in their technologies. It is rare to find society assisting science, but companies often assist societies. There are often calls for collaboration between science and society, although current science may not necessarily meet society's current needs but rather future needs.

Ms Young (Eskom Holdings) responded that IP in schools belongs to the school and student involved. Eskom does not manage or own that IP. Eskom only contributes towards the visibility of the project and taking it a step further to determine whether there is any commercial value in the project. Eskom does not take the project from the initial stage to the final result. Eskom endorses the project for further funding, thereby creating a pipeline for other companies to assist the learner and the school to take the project to completion. With regard to segregating the research from the customer and the needs of the customer, Eskom continually researches potential problems and strives to improve that research to ultimately reduce the electricity tariff for the customer. In terms of CSI, Eskom builds school halls, toilets and computer rooms and electrifies many schools that are without electricity and running water. Eskom's research projects therefore address the needs of its customer base.

Mr Schütz (CeRRI) responded that different groups have different needs and therefore it was easier to focus research on a certain group such as the needs of disabled people. CeRRI tries to be as diverse as possible in bringing new perspectives into technology in development. It is vital to distinguish between curiosity-driven science research and education, and relevant science and innovation. Today's research would require silos to be broken down between the various disciplines and sectors to enable the dissemination of free knowledge beyond the academic disciplines. Early stakeholder engagement is therefore crucial to the success of a project in order to realise the effective transfer of knowledge and results to one or all of the four sectors of the quadruple helix.

Dr Tacheba (Botswana Innovation Hub) commented that Eskom was undertaking a great deal of R&D together with other parties and queried how it ensured the protection of its IP. He also asked how Eskom dealt with the integration of foreign IP into its initiatives.

Ms Young (Eskom Holdings) responded that Eskom constantly undertakes research to provide cheaper and more efficient electricity to address the needs of its current and future consumers more effectively. The IP in the organisation is under investigation to be exploited to create various revenue streams. Eskom does not have a commercialisation unit but concentrates on its core business of generating electricity. When the window of local IP is small, it may be licensed out or given away, primarily in South Africa. This is handled by Eskom's Research Department. In terms of foreign IP, Eskom is bound to work with partners as the organisation is not allowed to become involved in renewable energy above generation.

A member of the audience commented that innovative research in the natural and physical sciences and engineering requires early stakeholder engagement. The disciplines and methodologies of the engineering sciences are very different from those of the social and human sciences. Very often natural and physical scientists are unable to engage using social science methodologies and therefore avoid stakeholder engagement, but the integration of the social sciences in technological development is becoming increasingly important. There is therefore a need to determine whether the relevant methodologies of each discipline could be transferred to other environments.

Ms Banda (African Women's Entrepreneurship Programme (AWEP)) commented that women, particularly in rural areas, are often unaware of initiatives such as the electrification of schools. Whilst society is appreciative of Eskom's initiatives, the organisation is generally slow in undertaking their projects. In Zambia, AWEP is working with two agricultural universities to educate farmers in 'smart farming'. Innovation and science need to work together.

Prof Muchenje (University of Fort Hare) advised that the results of scientific research must be transferred to society in order to keep society abreast of findings and new technologies.

Ms Young (Eskom Holdings) responded that Eskom has the Eskom Development Foundation, the Eskom Learning Institute and the Eskom College. Learning from research is taken into the classroom where students, scholars and artisans are trained and given on-the-job learning.

Mr Schütz (CeRRI) responded that during 2017, CeRRI would engage with people from the rural areas of Germany. CeRRI's approach is to establish dialogue with societal stakeholders at the beginning of research by means of exhibitions and workshops in order to identify their needs and answer their questions. Overcoming the barriers between the different disciplines is difficult, and scientists must be open to the methodologies of the various sciences in order to create awareness and overcome these barriers. It is not enough just to produce a prototype of a design; there has to be a need for the technology among the intended audience.

Mr Hlahane (Blue-Green Aquaculture, South Africa) commented that the generation of IP is expensive. It would be costly for entry-level businesses to prioritise IP without assistance in the form of 'hand-holding' from another institution. He asked what Eskom was doing in order to assist SMEs in this regard.

Ms Young (Eskom Holdings) responded that Eskom has no 'hand-holding expertise' but the need had been identified.

Ms Shinga (Department of Trade and Industry, South Africa) asked how collaboration was stimulated between the Fraunhofer institutes to ensure that they complement one another without competing among themselves. She also asked what support mechanisms were in place within Eskom to ensure the growth of young award winners.

Ms Young (Eskom Holdings) responded that through Eskom's Science Expo, projects were identified that have the potential to grow into something larger, for example, building a wind farm. Such projects are taken forward in collaboration with organisations such as the TIA, but are not funded by Eskom.

A member of the audience commented that policymakers play an important role in research and innovation. Politicians need to ensure that the requisite funding is in place, and research institutions should continually dialogue with politicians to ensure that their interest in projects is maintained and that funding is forthcoming as the projects develop.

Mr Schütz (CeRRI) responded that collaboration between the various research institutions does bring about competitiveness. New methods of participatory innovation can serve to increase the exchange of information and knowledge across disciplines, sectors and national borders.

SESSION THREE: FOCUS NETWORKING – Facilitator: Mr Stanley Maphosa, International Liaison Manager, ASSAf

Rapporteurs reported on the deliberations of the breakout groups.

Biotechnology for Agriculture – Facilitator: Mr Obakeng Maema, Technology Innovation Agency (TIA); Rapporteur: Ms Mmampei Chaba, Department of Science and Technology

The group had consisted of policymakers, researchers and entrepreneurs. It was clear that they all were aware of biotechnology solutions in some form. These included biotechnology innovations in the agricultural arena such as drought-tolerant, disease-resistant, herbicide-tolerant and insect-resistant crops and improved nutritional cultivars. The problem was the transfer of those innovations and technologies.

The group had considered how high and low-technology solutions could be translated into spinoffs. At the outset, low-tech solutions would have to be introduced, but mechanisms would need to be built in to assist societies to graduate from low-tech to high-tech solutions. Assistance would be required from governments in the form of policies to ensure that the funding cycle was in place from demonstration to piloting and upscaling. Civil society, non-government organisations and other influential groups would need to assist in the transition from low-tech to high-tech solutions and to raise awareness and change regulations to enable this transition.

The gap between conventional and biotechnological solutions had been discussed. Farmers need to understand societal challenges in order to accept and adopt high-yield cultivars and to cease producing low-yielding crops. The footprint of biotechnology needs to be built across the region in order to anchor the regional cooperation agenda on food security so that a consistent and unifying cross-national biotechnology governance framework can emerge.

Blue sky research is needed, but generally only governments or corporations can provide the level of financing required to address societal needs. Governments, researchers and policymakers are disconnected from the challenges that rural societies face. Programmes are needed that force government officials to spend time in rural societies in order to understand the challenges.

Public Health – Facilitator: Dr Makobetsa Khati, National Research Foundation; Rapporteur: Dr Isabel Kazanga, College of Medicine, University of Malawi

The group had comprised representatives of eight countries, namely Zambia, Tanzania, Democratic Republic of Congo, Lesotho, Malawi, Zimbabwe, South Africa and Germany. Key health challenges can be attributed to food insecurity, the lack of safe clean water and decent access to health care. Dilapidated structures and the lack of critical medical supplies in most African countries are evidence of the failure of government stewardship. Similarly, lack of investment in some privately run clinical centres has contributed to their ineffectiveness in delivering quality care to the indigent population. Another challenge is the increase in the brain drain.

The solutions would be increased investment in infrastructure and equipment to address both communicable and non-communicable diseases. Governments should increase budgetary allocations to health, and policies must be in place to ensure that the funds are appropriately proportioned and distributed. Integration and a holistic approach to health care is needed, whereby health care centres and professionals address both the physical and psychological needs of patients. Incentives should be provided to encourage health professionals to work in rural areas. Increased funds should be allocated to preventative programmes. The use of ICT would promote public health. The Teledoctor innovation in Zambia connects patients with health professionals around the world for advice on diagnostics and

treatment. Health education needs to be promoted at all levels to ensure that communities are empowered with information on health.

Information and Communications Technology (ICT) – Facilitator: Mr Lukonga Lindunda, BongoHive, Zambia; Rapporteur: Mr Nkateko Khoza (RAPX Engineering)

ICT is considered to be the fourth industrial revolution. The main challenges facing ICT in Africa are the lack of infrastructure and accessibility to ICT products, including the exorbitant costs of devices and internet usage. The positive aspects of ICT are that it represents a single global online world and provides efficiency in terms of educating large groups of people without having them in the same room. A negative aspect of ICT is the information security risks posed to users. Policy formulation by African governments has not kept pace with rapid technological development in ICT. Governments need to be more responsive in policy formulation. SADC countries need to coordinate in rolling out and sharing ICT infrastructure, which would result not only in decreasing the cost of infrastructure in the respective countries but also in the costs to consumers. Other challenges need to be discussed on other platforms.

Energy, Mining and Environment – Facilitator and Rapporteur: Prof Frank Winde, North-West University

It can be argued that mining is the oldest profession in the world. The human ability of extracting different minerals such as flint stone, iron, copper and bronze, in fact, are used by science to define and mark whole historical periods of human development. The SADC region is exceptionally rich in minerals, including some of the most precious minerals on earth, such as platinum, gold and diamonds, yet it remains one of the poorest regions in the world. While extraction of resources in remote areas can trigger development and urbanisation and help society to flourish as it has over the last 130 years in the goldfields of South Africa, it often also comes at a cost; an externalised cost that is, not borne by mining companies and their shareholders but the environment and local communities, e.g. by mines discharging untreated polluted water into the receiving environment and the costs of cleaning affected resources and the associated health burden falling on neighbouring communities. Such externalised environmental and social costs incurred during and after the operation need to be taken fully into account when planning and approving future mines.

Responding to the initially posed question whether mines are a curse or a blessing, the group concluded that this would depend on one's position in the mining business. Shareholders may say it is a blessing, and so would government, due to the ability of the mining industry to generate jobs and tax revenue, whereas a miner affected by occupational disease or a resident affected by dust and water pollution might see it as a curse. The group believed, however, that mining could be a blessing if it is correctly managed, but this had not been achieved yet in any of the countries represented. The track record of the mining industry is not convincing with respect to its environmental and social responsibilities in relation to its capital gains. In Angola, for instance, 25% of the revenue generated from oil cannot be accounted for, and in South Africa illicit outflows of gold-mining proceeds is also an acknowledged problem. Although there are many problems associated with the mining industry, it is still an economic backbone of many societies. In addressing these challenges, short-term gains must be balanced against long-term costs, many of which only become apparent long after the mines have closed. This is currently illustrated by the large financial and ecological burden of acid mine drainage emanating from flooded gold mines places on South Africa. So far, mines too often capitalise on the ambiguities of their effects on societies, where jobs, royalties and tax revenue outweigh their often delayed adverse impacts on the environment and health of people.

It is often said in politics that mining needs to be sustainable. The World Bank has recently provided substantial funding to the Centre for Sustainable Mining at UCT to promote research aimed at achieving this political aim. However, by its very definition, as the extraction of a limited resource, mining

cannot be sustained indefinitely as the example of groundwater use illustrates. While pumping out of groundwater is sustainable as long as less water is used than replenished such practice is sustainable. However, as soon as more groundwater is pumped than is recharged, the use become unsustainable as it will eventually be fully depleted. This is termed groundwater mining and a major problem in many arid areas around the world, including Africa. While any individual mine is thus by definition unsustainable, the industry as a whole must not necessarily be. One way of achieving sustainability is to turn closed mines and their legacies from being environmental liabilities into economic assets that allow communities to continue developing even after the mines closed. Apart from increased beneficiation of commodities by operating active mines it is through addressing the ever increasing challenges of mine closure and post-closure development that will determine SADC's success in turning mining into a sustainable industry.

One sector where mining plays a crucial role for sustaining society is energy. Here mines are both, major energy consumers and major energy providers producing coal, oil, uranium and gas still accounting for the overwhelming majority of the global energy use today. Even the rapid increase in renewable energy from wind and solar is dependent on mining as much of the high-tech materials needed for turbines and solar panels are sourced from mines. In fact, with the increasing use of rare earth elements – so called because of their low abundance in the continental crusts – mining is set to expand even further disproving the image of being a sunset industry. Cutting-edge research investigating the use of mines as future means to store the fluctuating energy coming from renewable sources, for example, has already yielded promising results soon to be applied in practice.

SESSION FOUR: INTELLECTUAL PROPERTY RIGHTS AND INNOVATIVE FUNDING OPTIONS – Facilitator: Prof Himla Soodyall, Director, Human Genomic Diversity and Disease Research Unit, National Health Laboratory Service and University of the Witwatersrand

Industries have shown that open innovation networks can be compatible with intellectual property rights. Companies such as Philips, IBM and Microsoft show how the transformation of their IP strategies has enabled effective open innovation. IP is used as a tool to enhance strategic alliances and to cross-license technologies, rather than using IP just as a defence mechanism. IP is not necessarily a barrier to open innovation. An intelligent IP strategy can act as a catalyst for open innovation through the leveraging power of licensing.

Intellectual Property Rights – Dr Kerry Faul, Head, National Intellectual Property Management Office (NIPMO)

Innovation is the primary driver of technological growth and drives higher living standards. Innovation is a multi-stage process whereby organisations transform ideas into new and improved products, services or processes in order to advance, compete and differentiate themselves successfully in the market place. It is universally accepted that IP and associated rights are a critical aspect of innovation and economic growth.

It is important to differentiate between IP and intellectual property rights (IPR). IP is often said to be a barrier to innovation and creativity, but it is typically not, although it could become a barrier if not managed properly. IP refers to creations of the mind and is divided into two categories: (1) industrial property rights for inventions, designs, plant varieties, trademarks and logos; and (2) copyright of persons for literary works, music, film, and computer programmes. Once protection has been secured, IP becomes a right and provides an exclusionary monopoly to prohibit others from using it without your permission.

Innovation has become a buzzword and is branded in numerous policies. The Organisation for Economic Development considers innovation as a means to drive technological growth and higher living standards. The Oslo Manual addresses the ability to determine the scale of innovation activities, the characteristics of innovative firms, and the internal and systemic factors that influence innovation as a prerequisite for the pursuit and analysis of policies aimed at fostering innovation. Innovation is the conversion of an idea that ultimately finds application. The core of all innovation relies on new knowledge in some form. This knowledge is IP, which holds at least one of the keys to our future.

A functional innovation ecosystem requires a plurality of players with efficient knowledge flows and networks, as well as aligned mandates for the transition of knowledge into innovative products, processes and services. The complexity of this system demands that the triple helix players (government, business and academia) work closely together at a synergistic level and with understanding of the various needs within the innovation process for the ultimate benefit of the fourth party in the quadruple helix, namely society. Collaboration, cooperation, open science, open networks and open innovation will all become critical as the world moves towards the fourth industrial revolution. We are on the brink of a technological revolution that will fundamentally alter the way we live, work and relate to one another. In its scale, scope and complexity, the transformation will be unlike anything humankind has experienced before, and the response to it must be integrated and comprehensive, involving all stakeholders of the global polity, from the public and private sectors to academia and civil society. The increase in big data will require collaboration between the triple helix players (government, business and academia) to enhance and to derive the greatest value from innovation value chains for the benefit of society. Most importantly, an innovation ecosystem needs to be appropriate for the environment; capable of adapting as required; and inclusive of design.

General awareness and understanding of IP is necessary if it is to become a tool for development. Once that awareness is in place, further education, explanation and elucidation of IPR may be required in order to enhance its inclusion in the national agenda and in business plans. Such could be nuanced for the various roles such as developers, researchers, managers, funders and end users or licensees of IP.

An IP framework policy needs to be developed and adapted to the environment. Africa has seven of the top ten fastest-growing economies and offers the highest return on investment of any region in the world. Africa's abundant natural resources, the growing consumer power of Africa's emerging middle class and favourable demographics offer enormous potential for sustainable economic growth and development across the continent. However, the continent still requires a transition from a commodities-based economy to a knowledge-based economy, coupled with large-scale industrialisation. In this transition, IP policies will be required to offset the development objectives of the country against the need to attract foreign direct investment; to address access to the system for local innovators; and to protect indigenous resources. Thus, a policy balance needs to be found that is appropriate to market conditions and conducive to growth. South Africa has rich indigenous knowledge and biological resources and it is therefore critical to have a complementary regime that protects biological resources.

South Africa's National Environmental Management: Biodiversity Act (*Act 10 of 2004*) ensures that indigenous resources are declared and that benefit-sharing agreements are in place with the relevant community in order to protect indigenous knowledge as far as possible. The South African Intellectual Property Laws Amendment Act (*Act 28 of 2013*) provides for the recognition and protection of certain manifestations of indigenous knowledge as a form of IP. The Intellectual Property Rights from Public Financed Research and Development Act ensures that IP emanating from publicly financed R&D is identified, protected, utilised and commercialised for the benefit of the people of South Africa. The IP rights related to South Africa's valuable indigenous knowledge systems will be better protected through the Indigenous Knowledge Systems Bill, which is intended to facilitate economic growth and spinoffs resulting from the application of indigenous knowledge.

Some examples of the application of IP include:

- The University of Limpopo has developed an *in vitro* method for the propagation of a Strelitzia species from seed. Mass propagation of some Strelitzia species through tissue culture has not been successful, but *in vitro* culture conditions have now been optimised to minimise oxidative browning. Patent applications have been filed in South Africa, Australia, India and Europe, as well as with the African Regional Intellectual Property Organisation (ARIPO). The method is commercially viable and allows for rapid mass propagation of Strelitzia, which will ultimately lead to job creation and a better life for the community.
- In the Western Cape, informal settlements are prone to rampant shack fires. UCT has developed a low cost fire-detection device that is coupled to a radio-frequency alert service. Provisional patent protection has been filed and detector software is copyrighted. This will assist with the safety and financial security of communities and provide improved quality of life.
- Energy security is a challenge, yet coal dust goes to waste. The Nelson Mandela Metropolitan University has developed algal biomass that uses algae for fuel production. A number of patent applications have been filed for the various technologies, which will result in composites being used as a substitute for coal in many applications.

Discussion

Mr Ndzendze (Eskom) commented that whilst there are a number of funding relationships in place with government to take innovation forward to commercialisation, such relationships rarely exist with institutions. He asked whether Dr Faul was aware of any such funding.

Dr Faul (NIPMO) responded that in terms of IP systems being accessible to innovators, funding would be required to take the technology forward to commercialisation. Various agencies were established to address funding. The TIA has three operational funding instruments: (1) the Seed Fund assists researchers from higher education institutions, science councils, technology entrepreneurs and SMEs to advance their research outputs and ideas for proof of concept, development of prototypes and business cases that could be used for further development through to commercialisation; (2) the Technology Development Fund assists innovators to advance technologies along the innovation value chain, from proof of concept to technology demonstration; and (3) the Commercialisation Support Fund prepares innovators for follow-on funding through limited support for market testing and validation. In this instance, TIA's role is to connect technology innovators to onward business and investment opportunities. TIA also provides for partnerships with technology stations for the development of technology. The Department of Trade and Industry (the dti) also has several funding incentive schemes that are geared to support various economic activities, including manufacturing, business competitiveness, export development, market access and foreign direct investment. Some of the prefunding programmes include: (1) the Innovation and Technology Funding instrument, which focuses on the development of commercially viable, innovative products and/or processes and facilitate commercialisation of such technologies; and (2) the Technology and Human Resources for Industry Programme (THRIP), which is a partnership between the public and private sectors to address the shortage of high-level technical skills for industry and to improve the competitive edge of South African industry through the development of advanced technologies.

Mr Ndzendze (Eskom) referred to the findings of a study in the North West province where people were loath to share their medicinal knowledge as they did not benefit from the sharing. He asked whether government intended to ensure that access to such knowledge was protected.

Dr Faul (NIPMO) responded that there were many concerns about the acknowledgement and protection of knowledge. Indigenous knowledge may become the catalyst for further research, and the ultimate product that is patented may be very different from the original knowledge. A non-disclosure or confidentiality agreement could be signed, but such an agreement is of very limited value and would need to specify word-for-word what the originator was disclosing. The National Environmental Management: Biodiversity Act plays a role in closing that gap.

A member of the audience commented that IP is sometimes reverse-engineered, for example, a Chinese company reverse-engineered some of CISCO's Square Kilometre Array project routers and put similar products at 40% of the price on the American market, resulting in the creation of thousands of jobs. Perhaps South Africa should consider the potential to grow the national economy through outside partners.

Dr Faul (NIPMO) responded that South Africa must ensure compliance with the Agreement on Trade-Related Aspects of Intellectual Property Rights administered by the World Trade Organisation (WTO), which sets minimum standards of IP regulation as applied to nationals of other WTO members. In South Africa, local content would need to be offset against the country's development needs. Africa tends to depend heavily on foreign direct investment (FDI), and countries need to acknowledge and accept that they will not become world leaders in certain technologies.

Dr Gabriel (National Technological Centre, Angola) commented that funding for patents for young innovators often presents a challenge and asked how South Africa addressed this.

Dr Faul (NIPMO) responded that the World Intellectual Property Organisation had recognised this challenge. The Inventor Assistance Programme matches developing country inventors and small businesses with limited financial means with patent attorneys, who provide *pro bono* legal assistance to secure patent protection. In South Africa, the TIA has developed the Youth Technology Innovation Fund, which

gives young South African entrepreneurs access to funding and assistance by means of a voucher system for patent attorneys to do the work free of charge. South African attorneys are required to do a certain amount of work free of charge to enable the less advantaged to access the legal system.

Mr Katati (National Institute for Scientific and Industrial Research, Zambia) commented on the disjuncture between scientists who are under constant pressure to publish their findings and businesses that are often hesitant to share their innovation technologies and asked how the two parties could be brought closer together.

Dr Faul (NIPMO) responded that the relationship would need to be determined at the outset. In South Africa the default position towards any new IP developed in a university is that the IP is owned by the university, which is obligated to commercialise it. The need to publish does not exclude the possibility of protecting the IP. Researchers should be encouraged to have their publications checked for new inventions by their office of technology transfer and seek legal advice and protection prior to publication. Once the IP has been published it is no longer possible to seek protection. Researchers on government-funded grants generally have considerable latitude in deciding how to take IP forward. Researchers should bear in mind that patent applications require only a sufficient description of the invention and they are not bound to disclose everything.

Innovative Funding Options – Mr Imraan Patel, Deputy Director-General, Socio-economic Innovation Partnerships, Department of Science and Technology

In South Africa, innovation is not only about funding but about partnerships between industry, science councils and society, with a larger focus on business rather than society.

The DST operates a number of co-funding initiatives:

- The Technology Stations Programme, modelled on a German programme, provides dedicated funding to universities of technology to focus on industry support, mainly to SMEs. A recent assessment of the programme was conducted in order to determine its success and whether it should be scaled up. Over the years the universities of technology had managed to develop some of the most cutting-edge technologies for commercialisation. The DST provides technology stations with funding to support SMEs. The stations also attract partners from the private sector.
- The Technology and Human Resources for Industry Programme (THRIP) and the Support Programme for Industrial Innovation were initiated by the dti to address the challenge of building human resources capabilities. These instruments have gone through various iterations. The key requirement for both programmes is co-funding, which is not simply a case of securing additional funds but an indicator of the relevance of the research.
- The Sector Innovation Fund has an explicit requirement for co-funding. Government must recognise the importance of partnering with industry associations. The Post-Harvest Innovation Programme, for example, is a public-private partnership between the DST and the Fresh Produce Exporters' Forum aimed at the development of innovative technology in the postharvest leg of the fresh fruit value chain in order to develop and maintain the global competitiveness of the South African fresh fruit industry.
- Centres of Competence provide opportunities for commercialising research, maximising profits, research development and overall development for South Africa and its partners. The centres take advantage of a market opportunity to help South Africa to gain a competitive advantage by using the innovative capacity of universities and research communities, while contributing towards human capacity development. One of the successes of this programme has been the Anglo American Platinum hydrogen fuel cells technology, which is successfully being used to provide standby power in schools in the Eastern Cape. The DST has partnered with the Bill & Melinda Gates Foundation to form the South African Sanitation Technology Demonstration Programme in order

to determine the suitability and uptake of innovative new-generation sanitation in South Africa. In this partnership the DST is investing the larger portion, but the spinoff is access to the global network and partners of the Bill & Melinda Gates Foundation.

- The DST has recently joined the Global Innovation Fund. Whilst the DST invests only in South African research, it is able to access the global network of knowledge.
- Science parks, Maker labs, mLabs, Living Labs and Fablabs are initiatives that provide facilities for collaboration to attract co-funding partners.
- Industrial development and scale-up facilities are a new innovation involving the CSIR to look at applications apart from R&D for industry-led projects that require the use of such facilities to accelerate development and commercialisation, for example, chemical and nano-based technologies. These facilities create a national facility to take R&D into industrial development and attract parties from the private sector.
- Private companies may install research equipment and infrastructure at a science council. For example, a company installed R&D facilities at Mintek, which were dedicated to that company's research for a two-year period; after completion of the research the equipment was 'donated' to Mintek.
- Joint research centres have been set up with science councils and have proved to be of value, particularly in the context of state-owned enterprises. The CSIR and Transnet have a very successful facility where Transnet engineers work with CSIR researchers to evolve technologies together. The real value of such an undertaking is not in the funding alone but in the opportunity for engineers to work together with researchers.
- The DST has a significant portfolio of Inclusive Development Partnerships where companies see opportunities to create new value. An example of such a partnership is the hydrogen fuel cell technology that is being used successfully to provide standby power in remote rural schools. The developing company provided the equipment and infrastructure, resulting in the formation of a value-added partnership.

Through its socio-economic innovation programmes, the DST builds partnerships with companies to enhance the growth and development priorities of government through targeted science and technology-based interventions and the development of strategic innovation partnerships with other government departments, industry and the public science system.

Discussion

Ms Moribame (Botswana Institute for Technology, Research and Innovation) commented that it is often difficult for government to capture the interest of industry players in public-private programmes and asked what the DST did in in this regard.

Dr Gabriel (National Technological Centre, Angola) asked what would be required in order to involve universities in innovation partnerships.

Mr Patel (DST) responded that for universities to participate in the national innovation system, they would need to own their own technology stations and take ownership of research. Technology stations have been shown to provide value by fostering an understanding of what society needs. They provide companies with subsidised services and assistance in product design, development and manufacture as well as assisting them to become more competitive through technology transfer.

There was a question about the size of innovation funding.

Mr Patel (DST) responded that there were seven sector innovation funds, with funding ranging from R5 million to R25 million over three years. The Sector Innovation Fund is not a short-term intervention, and its real impact only becomes evident over time. The challenge is to convince National Treasury that such

instruments can have enormous positive results for the country. It is important to continue the expansion of such programmes to make it possible for initiatives to move out from the academic world and for government to become a vigorous change agent for development in both the private and public sectors. By treating questions of science, technology and innovation as questions of state, countries take a definitive step forward as players on the international stage.

A comment was made that the Transnet campus at the CSIR was very impressive and that it was relatively easy for a state-owned entity to implement such a facility. The question was posed as to how the private sector could be involved in a similar way and how the technologies could be exploited.

Mr Patel (DST) responded that strong partnerships were built on trust. Partners acknowledged that apart from the financial support received from the Sector Innovation Fund they had also welcomed the understanding of how the public STI system operates, while the DST had gained valuable insight into what drives the private sector.

Successes such as the Transnet/CSIR facilities need to be expanded on. A further example is titanium additive manufacturing, which is an important technology building block in the Titanium Industry Development Programme. Over the past five years, the DST had supported the development of capability for a successful titanium metal industry in South Africa. This technology has the potential to introduce major efficiency improvements for the aviation industry that could position South Africa as a world leader in the cost-competitive production of high-grade titanium metal powder and components. A recent visit by the industry partner provided valuable insights that forced the DST and CSIR to revisit the strategy for the project. In this type of partnership, a co-partner would need to be sourced to commercialise the product.

Mr Hlahane (Blue-Green Aquaculture, South Africa) asked whether there was a repository of failed or stalled projects. If so, revitalising these projects might serve to address current problems. Mr Hlahane commented that science and technology do not have a local presence in all provinces. He suggested forming partnerships that straddled all provinces rather than focusing research efforts in only a few provinces.

Mr Patel (DST) responded that there are many failed or stalled projects, but information on such projects is lacking. There needs to be a complete digitisation strategy not just to learn from such projects but also from discussions on social media. There are initiatives to revitalise old and new technologies. Companies may review their previous technology projects so as to be better informed for different and more modern approaches. In SADC countries where there is not much historical legacy, countries would need to implement a digitisation strategy from the outset.

Mr Patel (DST) advised that government leaders across the continent have been urged to ramp up investment in technology and innovation in a bid to drive growth at municipal level. Some South African examples include: (1) the DST Spatial Temporal Evidence for Planning South Africa initiative, known as StepSA, is a support tool aimed at promoting innovation and evidence to support effective service delivery and high-impact public investment in cities, towns and rural settlements; and (2) the DST in partnership with the Human Sciences Research Council (HSRC) has developed a municipal innovation maturity index that can be used to assess the level of maturity of cities and municipalities in adopting innovation and technology to improve service delivery.

The DST and other government institutions have evolved to provide comprehensive support to small businesses. These services benefit an increasing number of small businesses but significant gaps still remain, particularly improved integration of the support provided by the various programmes. The DST constantly strives to increase entrepreneurship. Partnerships between government and various stakeholders and role players remain a critical success factor. The DST has been encouraged by the increasing involvement of the corporate sector, organised business, private financing institutions, non-govern-

mental organisations, universities and the media to foster entrepreneurship and small business. Effective networking, adequate skilling, mentoring, good business acumen and sound principles and practices are essential to build a winning culture. The DST through its Technology Localisation Plan supports approximately 49 companies.

A member of the audience asked whether the DST initiatives also provide funding for SMEs in the SADC region. Mr Patel responded that SADC member states needed to increasingly invest in innovation and technology capabilities to enable them to upgrade and expand their manufacturing base. Innovation and technology processes are knowledge, skills and resource-intensive if market failure is to be avoided.

Day 1 Recap, Wrap-up and Closing – Prof Himla Soodyall, Director, Human Genomic Diversity and Disease Research Laboratory, National Health Laboratory Service and University of the Witwatersrand

Prof Soodyall expanded upon the analogy of the marriage between science, business and society. The day had started with the opening address and three presentations during which the speakers had shared their personal perspectives.

Prof Diab in her opening remarks had asked the audience to think about the relationship of the theme of the conference – namely science, business and society – as a marriage. She highlighted that this marriage had elements of 'the good, the bad and the ugly', but if nurtured by opening channels of communication, the conversations that followed would contribute to enhance and strengthen stronger partnerships towards a common goal.

Following on this marriage, conception had occurred, albeit of a different kind. In September 2016, a baby was born as a result of *in vitro* fertilisation technology, drawing on a three-parental genetic contribution. This had been a very controversial matter, which had given rise to a number of ethical issues. Britain had endorsed a law to allow three-parent conception, which comprises a mother and a father who, as two of the parental lines, contribute their nuclear genes to the germ line or DNA of the offspring. A third parent, a female, contributes her mitochondrial DNA as the third parental line. This is analogous to the theme of science, industry and policymakers, with society as the surrogate mother completing the quadruple helix.

Mr Schütz had spoken about the quadruple helix. We should celebrate the quadruple birth of the integration of the three germ lines or the DNA of this new life by bringing together science, industry and policymakers, as well society as the uterus that will house this germ line. Society is challenged with many issues, and scientific innovation is the key driver of growth. Similarly with the conception of a foetus, certain drivers are required to nurture its growth. An enabling environment must be created that is conducive for the growth and development of the foetus and the resultant offspring. In his address, Professor Petersen had spoken about roadmaps. In order for the foetus to grow in an enabling environment, it must be subjected to scans in order to map and monitor its growth and development. Whilst the gestation period is under way, society as the surrogate mother faces many challenges from both the international and national environments. The foetus will have to endure challenges including costs, access to resources, the lack of appropriate mechanisms for effective uptake and better alignment for comfort as it grows. It should not be forgotten when darkness prevails due to load shedding, there is a direct line to Eskom. This was highlighted in the presentation by Ms Young, who related many of the good things that Eskom has done and continues to do.

It is best for the offspring when delivered to have one's house in order. The offspring must be nourished with food, for example. Whether that food should be organic or genetically modified will be addressed in the biotechnology breakout group. Decisions are needed on the respective merits of public and private health systems. The offspring would need to be communicated and stimulated. Research has shown that mothers-to-be should play classical music and speak to the unborn baby to develop its neu-

ral architecture. We need to take advantage of ICT infrastructure to provide a better enabling environment. There is a plan for this baby from conception to birth, as it takes its first few steps as a toddler and experiences the challenges of a teenager. We were privileged to have Dr Faul to inform us about the IP rules. Three-parent conception will have its challenges, which will require legal advice. Government must ensure that the right decisions are made with respect to the various initiatives at hand.

The analogy highlights how society is the incubator for the many issues that members of society need to be aware of. Time is needed to address these challenges. In the context of science, business, industry and society, the participants are all specialists in their own micro environments. The lessons learned from the various contributions highlight the need for society to become apprentices in a macro environment. The voices of business, government and science all have drivers that shape the way these sectors work, but the public sector must make its contribution by grappling with the various components so as to alter the macro environment in a favourable way. The conversations have informed us that a more holistic way of thinking must be adopted. The challenge is to take steps with more openness not only with respect to disciplines but also people.

Science is a pipeline: there are many activities associated with science, and there are many actors who play their roles within the various sectors. Ethical issues, legal issues and issues of societal relevance all need to be taken into consideration. Research is generally not a profession in itself but a component of the activities of the sectors from which the actors come. The priority of academics is to teach and generate knowledge, but when coupled, government policies require that innovation should lead to income generation. There needs to be awareness of these demands.

Prof Soodyall thanked the facilitators of the various sessions, the rapporteurs who presented the feedback from the breakout groups, the hosts of the conference (ASSAf and Leopoldina), the staff of ASSAf for their role in organising the conference and all participants for their active engagement in the deliberations.

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SESSION FIVE: THE ROLE OF SCIENCE FOR INDUSTRIALISATION IN THE SADC REGION – Facilitator: Ms Mmampei Chaba, Chief Director, Department of Science and Technology

Ms Chaba welcomed the participants to the last day of the conference, which had commenced with a 'wedding' and closed with the 'birth of a child'. She intended to continue with the analogy of raising a child. Knowledge would be transferred and shared in order to take the child from adolescence to adulthood. In this process, the child would learn to implement its learning and fulfil its mandate.

In April 2015, SADC heads of state adopted a strategy for the industrialisation of the SADC region. The strategy addresses six key binding constraints, namely infrastructure, energy, transport, ICT, water, and education and training. Business, policymakers, researchers and society must address these challenges in order to implement and build a vibrant and dynamic industrial sector in the SADC region for a better life for all.

Setting the Scene – Dr Christiane Diehl, Deputy Head, International Relations Department, Leopoldina

The previous day had provided an insightful overview of science, business and society dialogue in the SADC region. The audience had heard about early stakeholder involvement for research and about business-driven initiatives in the science business dialogue. During the breakout groups, participants from science, business and policy had connected and exchanged ideas in sub-groups: (1) Biotechnology for Agriculture, (2) Information and Communications Technology and (3) Energy, Mining and Environment. This had been followed by key inputs on IPR and innovative funding options. Dr Diehl complimented Prof Soodyall on her memorable closing address when she had likened the dialogue between science business and society to a three-parent conception and set out the different steps for the development of the resulting foetus.

The recurring themes and highlights were the perceived lack of public investment in R&D, the need for inter-sectoral flexibility, and acceptance issues related to science in society, such as questioning of the use of public funds for scientific research or the rejection of scientific innovations that are not well understood by society. The conference had discussed the importance of regional integration within SADC and the specific languages used by different communities of experts. Hope rests on science to deliver solutions to address the global grand challenges. A complementary issue is the need for scientific and vocational training. The innovation ecosystem needs to be more fluid and adaptable.

Industrialisation in Africa can be realised through well-functioning dialogue between science and business and through the role that science can play in stimulating and fostering industrialisation in the SADC region. The presentations would demonstrate the power of young and female researchers in the science-business dialogue. A sustainable and fruitful dialogue between science, business and society would require concerted efforts to fully integrate young and female researchers.

The breakout sessions would encourage participants to apply some of the topics and perspectives to case studies in public health, ICT and mining. The case studies would be followed by a panel discussion to draw together the discussions from the last two days. Dr Diehl expressed the hope that strategies would be devised for better dialogue between science, business and society. Finally food security, sustainability and agriculture would be discussed.

Dr Diehl wished the conference well and encouraged participants to connect with one another and with the contributors and panellists. A list of attendees and their contact information would be emailed to participants in order to encourage networking.

The Key Drivers of Science Industry Collaborations in Service of Society – Ms Lynette Chen, CEO, NEPAD Business Foundation

NEPAD had signed a memorandum of understanding with the SADC Secretariat in order to mobilise the private sector to lead, own and participate in the SADC Industrialisation Strategy and its implementation.

The NEPAD Business Foundation is a non-profit organisation formed to achieve goals of the New Partnership for Africa's Developments (NEPAD) to grow economies and livelihoods; to provide critical linkages between the public and private sectors with the intention of accelerating development projects from inception to implementation for the prosperity of Africa; and to promote sustainable economic development in Africa through the private sector. NEPAD acts as a project management unit to catalyse, coordinate, unlock and accelerate project development in Africa, from concept to bankability, through public–private and development of finance partnerships.

An effective STI policy relies on the collaboration of key stakeholders including government, research institutions, industry and firms. This cross-stakeholder cooperation is required to formulate policies and to ensure their implementation. Science policy entails investment in R&D and in the development of human capital through education and training. Technology policy focuses on the development of technological infrastructure to support the development and utilisation of existing and new technologies. Innovation policy focuses on actions by public organisations to help develop the capabilities and capacity of firms to innovate. These three policies are inextricably linked.

Research points to emerging economies and newly industrialising nations achieving greater economic success where they have the ability to formulate effective science, innovation and technology policies. National policies are geared towards enhancing the capacity and capabilities of local companies in order to allow them to innovate and compete internationally. Local firms' abilities to take advantage of the policy environment to continually innovate can become a critical competitive advantage for the domestic economy.

A lack of institutionalisation of innovative capacity leads to constrained potential for industrialisation through downstream value-addition. Factors inhibiting innovation include distances from end-user markets, poor infrastructure and logistics networks, poor trade facilitation frameworks and the lack of application of good business practices. These factors are prevalent on the African continent and contribute to the poor economic growth of some countries. In small developing countries in particular, industrial centres of competence offer a real opportunity to transform marginalised economies. An example was cited of a NEPAD project in the SADC region dealing with landlocked and oceanic states that often have to generate their own forms of economic activity. Geographical factors put landlocked developing countries at a distinct disadvantage in the development process. The lack of access to the sea, remoteness and isolation from major international markets result in prohibitive transit costs and create formidable obstacles in importing essential items and exporting goods. Consequently, landlocked developing countries find themselves increasingly marginalised in the globalising world economy. Excessive transit costs have become more of a significant barrier than tariffs. The success or failure of trade of landlocked developing countries is largely determined by the availability and cost of transit transport.

African governments, supported by the development community, have spent consistently on the development of small businesses in an effort to develop entrepreneurship. Despite this expenditure, Africa still sees no overwhelming net positive industrialisation effect, and unemployment continues to rise. African economies have not competed with the newly industrialising and emerging economies of Asia and Eastern Europe, while Latin American countries have been experimenting in innovation. The Middle East has overtaken Africa in terms of innovation metrics.

The Global Innovation Index 2016 gathers data from many sources, covering a large spectrum of innovation drivers and results. It looks at how countries are enabling innovative activities through their knowledge, technology and creative outputs. The highest-scoring country in the world is Sweden with 66.3%. The highest-scoring country in Africa is Mauritius with 35.9%, followed by South Africa at 35.8%; Zambia scored 19.9%. These scores highlight the need for investment in STI in Africa.

In the 1960s, Korea launched its first industrialisation drive. Korea was a developing country with a poor resource and production base. It had a small domestic market and was dependent on foreign powers for national security. Korea's GDP in 1961 was $2.3 billion, or $82 per capita. The country was predominantly agrarian, with manufacturing accounting for only 15% of GDP. International economic interactions were very limited. In 1961 Korea's exports totalled $55 million and imports $390 million. By 2015, Korea's GDP had risen to $1.849 trillion, with exports making up 28.5% of the country's total output ($526.9 billion in 2015). Over the past four decades, the country has demonstrated enormous economic growth and global integration to become a high-tech industrialised economy. In the 1960s, GDP per capita was comparable with levels in the poorer countries of Africa and Asia. By 2015, Korea had a labour force of 26.89 million and unemployment of only 3.5%. The country's current account balance in 2014 and 2015 was $84.37 billion and $105.9 billion respectively.

In the 1960s there were only two public institutions for scientific research and technological development in Korea: the National Defence R&D Institute created after the end of the Korean War, and the Korea Atomic Energy Research Institute. The government invested $5 million which created fewer than 5 000 employment opportunities for research scientists and engineers. In 1962, Korea launched the First Five-Year Economic Development Plan, which generated huge demands for new technologies. Korea's policy strategy was geared to promoting the inward transfer of foreign technologies while at the same time developing domestic capacity to digest, assimilate and improve upon these transferred technologies. The Korean government implemented a policy that restricted foreign direct investment (FDI) in order to protect local ownership and control of the economy. It also focused on reverse-engineering following detailed examination of its construction or composition. There were major sources of technological learning through original equipment manufacturing (OEM) production where a company's products are used as components in the products of another company and the value-added reseller customises designs based on that company's needs. Korea entered into foreign licensing agreements that helped Korean companies expand their product lines in the international marketplace whilst lowering the financial risk of the expansion.

In the 1970s, Korea's development target was shifted to more capital and technology-intensive industries with the implementation of massive investment projects to build up machinery and chemical industries. In 1982, the Korean government recognised the need to build indigenous R&D capabilities. This recognition led to the launch of the National R&D Programme with the aim of promoting and facilitating private sector R&D activities, which were encouraged through tax credits. The overall government strategy of exposing firms to international competition was implemented. Companies were provided with financial and other incentives based on export performance; those that performed better were given better business opportunities as well as better access to financial resources. Korean firms recognised that to keep pace with technological change and survive in an export-driven world, they would have to invest heavily in R&D.

The National R&D Programme had both positive and negative effects. The policy enabled Korea to acquire technologies at lower costs and precluded the constraints often imposed by multinational companies on local firms' efforts to develop their own capabilities. Korea had to forego access to technologies that might have been available through direct equity links with foreign firms. Without FDI, Korea failed to meet global standards in domestic business operations, and the reliance on large-scale foreign loans contributed to a major financial crisis in 1997. Korea was able to succeed, however, largely because of

the informal modes of technology transfer that emphasised a well-educated workforce. In 1965, R&D expenditure amounted to $8 million. The ratio of investment between government and the private sector was biased towards government at 61:39. In 2005, R&D expenditure amounted to $213 582 million with the ratio of investment between the government and the private sector being biased towards the private sector at 24:76. In 1965, there were no R&D centres, whereas over 11 000 R&D centres had been established by 2005.

Korea is a good example of how a small nation was able to transform its economy and become a global competitor through its investment in R&D. The NEPAD Business Foundation's approach to innovation is aligned to five thematic areas, namely agriculture, climate change and natural resource management, economic and corporate governance, human development and capacity building, regional integration and infrastructure. In terms of regional infrastructure, cities need to become smarter through the use of technology. Of the global population, 4.1 billion people have no online connectivity, 800 million of whom are in Africa. Beyond communication, for every ten people who become connected online one person gets lifted out of poverty because they get access to tools for education and for finding jobs. Cheaper data and accessibility needs to be provided across the continent. People need to be made aware of issues such as education and health, which are available online in many languages.

In Ethiopia, the NEPAD Business Foundation is building on Africa's technological R&D capacity through a regional cluster. The foundation is currently advocating for an East African Technology and Open Innovation Campus, which will gather together East African science and technology ministries, research centres, academia and centres of excellence in one place. Dedicated ICT desks have assisted African start-ups to inspire entrepreneurships. The establishment of centres of excellence around ICT using local people and knowledge is being investigated.

In the SADC region, science and technology can be used to develop and strengthen national systems of innovation in order to drive sustained socio-economic development and the rapid achievement of the goals of the SADC common agenda including poverty reduction and eradication. The Protocol on Science, Technology and Innovation was signed by SADC Heads of State and Government in 2008. The objective of the Protocol is to foster cooperation, promote the transfer and development of resources of science, technology and innovation in the region, optimise public and private investment in R&D and leverage external contributions. The Protocol created institutional mechanisms for managing and administering STI at a regional level. These policies and strategies should focus on attracting sustainable, high-quality FDI with associated positive spill-over in local supplier development, skills development and technology development, with a balance between increased domestic demand and balancing imports and exports. A proportion of these benefits should be consistently ploughed back into R&D to support innovation. This highlights the importance of public-private collaboration with expert engagement with academic and research institutions.

Various barriers to doing business in the SADC region have been cited, including the lack of access to and the cost of finance, tax rates and administration; access to skilled labour; economic and regulatory policy uncertainty; exchange rate and foreign currency fluctuations; customs regulations, procedures and bureaucracy; inefficient bureaucracy; non-tariff and other trade barriers; the supply of reliable and efficient infrastructure; and corruption. It is imperative for the private sector to be involved in industrialisation. It is estimated that 70% of Africa's output and approximately two-thirds of its investment and 90% of employment are generated by the private sector. Therefore private sector perspectives must be considered in the formulation and generation of the Regional Industrialisation Plan. The private sector would influence and target industries and support value chains across the borders; it would address infrastructure requirements for energy, water and transport. Private sector perspectives could influence policy and legal amendments and any practical incentives required to enable investment. The private sector could provide useful information and successful examples with regard to value chain management and the involvement of SMEs in those chains, including the description of on-the-ground challenges and

solutions for different commodities. In the context of local-content requirements, supplier development and inclusive business models must be encouraged.

The role of the business community in southern African regional trade, investment and industrial policy formulation is crucial as private-sector players are implementers and are often the intended beneficiaries of such policies. There has been an increased call from governments and development agencies for the private sector to play a greater role in the economic and social development of Africa in order to ensure long-term sustainability and growth. When the business community is engaged early in business projects, it is much more likely that there will be buy-in from key stakeholders and that the design of processes will have a real impact on regional economic integration in SADC.

To give momentum to public-private dialogue in SADC, the inaugural Southern African Business Forum (SABF) meeting was hosted in 2015 in Gaborone, Botswana. One of the outcomes of the meeting was the Savuti Declaration, which covers the key messages on promoting socio-economic cohesion. In the declaration, the private sector of the region calls for the implementation of SADC's extensive plans for regional integration, industrialisation and infrastructure development. In particular, action is required in the focus areas of industrialisation; the movement of goods, services and business people; a railway development master plan; an enhanced mechanism for dealing with non-tariff barriers; and access to energy and water. The SABF will become the formalised structure for private engagement and partnership with SADC to enhance the private sector's role in achieving regional integration through cross-border investment and trade. To facilitate dialogue and engagement between the SADC Secretariat and SADC member states on the one hand and the private sector doing business in the region on the other, working groups were established which consist of regional private sector representatives and relevant SADC officials with the aim of developing potential solutions to the challenges highlighted to doing business in the region, as well as jointly shaping projects that can unlock the region's socio-economic potential.

At the second SABF summit held in Swaziland in August 2016, four common messages emerged:

(1) Hard and soft infrastructure shortcomings must be addressed together. Hard infrastructure is only as useful as the regulatory environment that surrounds it and either permits or hampers its utilisation.

(2) Policy certainty, including stability, predictability, consistency and transparency, is a prerequisite to attract investment for regional industrialisation, regardless of sector or scale. Large companies and SMEs from all sectors demand policy certainty regarding the use of tariffs, fees and levies at borders; mining houses and agro-processors call for stable and predictable export regimes; and infrastructure developers and agro-enterprises raise the need for consistent and transparent land use rights.

(3) Prioritisation and sequencing are the key to successful implementation. Prioritisation should take into account geographical links, opportunities for incremental implementation to allow for short-term gains, and industry-specific requirements to support priority value chains.

(4) Enabling trade through the removal of non-tariff barriers, coordinated border management and a solid regional transit system is a prerequisite for industrialisation in all sectors.

The SABF's Esibayeni Declaration approved investment in centres of excellence across all sectors, including agro-processing and mining, to adopt a regulatory environment that encourages innovation and up-skilling to ensure that industries have access to the human resources required for moving into higher value-added activities.

Two key initiatives of the SADC Pharmaceutical Working Group are the SADC collaborative process in medicines registration (Zazibona) and the SADC Medicines Databank. Zazibona is a process of collaboration between national medicines regulatory authorities and is being rolled out in South Africa, Zambia,

Zimbabwe, Botswana and Namibia. The objective is to promote a collaboration model to facilitate access to good-quality medicines through work sharing in the assessment of medicines and the inspection of medicine manufacturing and testing facilities. Two countries would need to test and prove the medicines; they would then be automatically allowed into the remaining SADC states. This would reduce the registration time for medicines from seven years to nine months.

The Medicines Databank is a centralised SADC portal of medicines and tenders for medicines to harmonise procurement and standards and benchmark prices of medicines. In terms of market access, companies would be able to establish the demand for medicines on a regional basis in order to invest in local factories or R&D facilities, as well as investing more into local content.

The Strategic Water Partners Network, in partnership with the South African Department of Water and Sanitation and private sector companies, comprises various working groups, one of which is the Agriculture and Supply Chain Working Group. The Water Administration System, developed by a South African entrepreneur, Dr Nico Benadé, is a uniquely South African-integrated management tool for managing water releases and online water order placements for irrigation schemes. The system has resulted in a saving of 927 891 m^3 of water per week, which equates to approximately 48 million m^3 per annum. Four schemes were piloted in 2015 and a further five were implemented in 2016. National Treasury is considering funding another 13 schemes during 2017.

The Fast-Moving Consumer Goods Working Group advances border cooperation and harmonisation at key border posts and assists the region in removing non-tariff barriers highlighted by businesses, such as the cumbersome completion of paperwork, delays at border posts and infrastructure challenges. The technology solution is to create a centralised SADC portal for registration and product certification harmonised across borders.

Science and technology in the SADC region will assist in developing a region where science, technology and innovation drive sustainable social and economic development, alleviate poverty and disease, and underpin the creation of employment opportunities and wealth.

The Role of Science for Industrialisation in the SADC Region – Dr Thulani Dlamini, CEO, CSIR)

STI on its own is not sufficient for industrialisation within the SADC region. Other driving forces are the increased local demand for goods and services, changes in income levels, quality of life and education, the availability of skilled labour, the creation of new trade networks, the availability of relevant resources including capital, and the culture of innovation and entrepreneurship. These key drivers place pressure on the region to industrialise quickly in order to remain competitive and not to fall behind the rest of the world. The region needs to remain competitive and transform economically and technologically through the accumulation and dissemination of knowledge, and the development of modern infrastructure and human capital.

Science and technology are important enablers of strategy. Higher levels of growth and deeper structural transformation are required to make this happen. In terms of global competitiveness, the SADC region must move away from an economic growth path built on consumption and commodity exports to a more sustainable developmental path based on industrialisation. Linked to this is the need to build economic infrastructure and to enhance the technology base and competitiveness of industries. An integrated regional market is critical in generating economies of scale to unlock the region's industrial potential and enhance the competitiveness of domestic firms.

The structure of production of SADC countries is characteristic of a developing region where large shares of GDP originate from primary-production sectors, mainly agriculture and mining, but value addition in these sectors remains low. With the exception of South Africa and Mauritius, which have size-

able manufacturing sectors, the SADC industrial sector remains relatively undiversified. Industrialisation in SADC is imperative and needs to move from academic discussion to real implementation. SADC governments need to introduce and implement policies and strategies that support industrialisation by providing a secure foundation for scientific and technological growth, prioritising the development of industrial technology and creating a favourable climate for science and technology through legislation. There is a critical need for structural transformation in SADC. The core challenges confronting the manufacturing sector in SADC member states include limited domestic markets, insufficient productive capacity and diversification, limited cross-border industrial linkages, over-reliance on primary production with limited value-addition and beneficiation, low levels of investment in manufacturing activities, and low levels of intra-SADC and external trade in diversified products. Industrial competitiveness is hampered by a shortage of skills at firm and policymaking levels; inadequate access to capital; dated technologies and methods of production; poor standards, quality and conformity infrastructure; and inadequate logistics infrastructure.

By combining the talent of its people and its technological advantage, Sasol has been a pioneer in innovation for over six decades. From 1937 when Anglovaal acquired the rights to use foreign technology in South Africa, followed by the incorporation of Sasol as a state-owned entity in 1950, Sasol today remains a leader in using foreign technology to drive innovation. In 2004 the company started sourcing gas from Mozambique and now owns two gas-to-liquid plants, one in Qatar and the other in Nigeria. Sasol remains one of the country's largest investors in capital projects, skills development and technological R&D.

SADC governments need to approach the challenges of industrialisation by developing strong policy foundations that will address the public's perception and interest in the Southern African Business Forum (SABF). Strong institutional organisations as well as R&D systems must be developed to attract and retain suitable talent in science, engineering and technology (SET) and drive towards excellence, as the limited scientific manpower with skewed distribution limits the possibility for multidisciplinary research and technology. The region will need to move beyond its heavy reliance on imported technologies and deal with the lack of research equipment and information resources. Furthermore, it will need to develop the ability to fully assess the economic impact of R&D leading to an optimal innovation portfolio in order to improve co-operation between producers and consumers of technology.

In terms of human capital development, SADC countries need to increase their spending on education at all levels, and to strike a balance between technical and vocational training. Tertiary education institutions need to produce the requisite number and quality of graduates in STEM education. A closer working relationship should be developed between higher education institutions and industry so as to produce graduates that are relevant to the economy. Regional quality standards are required in order to facilitate the movement of human capital in the region.

The SADC region needs to consider various growth pillars for the industrialisation of the region. These include an increase in domestic demand and the exploitation of the agricultural economy and natural resources in order to create new opportunities. Opportunities to maximise exports must be investigated. The service industry must be developed and opportunities created for domestic, regional and global value chain participation.

Technologies should be introduced that are appropriate for the level of development. The industrial base needs to be broadened and diversified, and should target mechanisms to address industrial and technological gaps. Regional value must be developed to ensure access to global markets. Inequality must be addressed by focusing on the education and employment of youth and women in industry. The region must shift from factor accumulation to factor productivity by employing more labour and capital for the efficient deployment of resources.

Engagement between the public and private sectors is critical. The private sector must be involved in the development and implementation of industrialisation strategies. It must create platforms for regional dialogues on industrialisation between the state, the private sector and society. State policies need to be informed of private sector requirements in order to improve alignment and the ease of doing business in the region and globally. Furthermore, it is imperative for SADC states to provide mechanisms and incentives for the training and development of entrepreneurs and SMEs.

Developing human capital at all levels is essential for any industrialisation endeavour. Investment in infrastructure and state-of-the-art technologies relevant to the region's level of development must be prioritised. A conducive SET policy environment must be created to support scientific excellence, innovation and entrepreneurship. Significant improvements in factor efficiency and regional integration are required to achieve global competitiveness. A balanced two-pronged approach must be considered for industrialisation based on maximum value addition of local resources and importing foreign technologies to drive diversification, import substitution and export expansion.

Discussion

Mr Hlanane (Blue-Green Aquaculture, South Africa) enquired what percentage of GDP had been spent on Sasol during the apartheid era, and what percentage of its turnover Sasol was currently ploughing back into the country.

Dr Dlamini (Sasol) responded that Sasol was originally funded through a loan from the Industrial Development Corporation and had benefited from the protection of the state during periods of economic decline. Sasol employs over 34 000 people worldwide, of whom more than 8% are employed in South Africa. The company brings in considerable foreign income through its international operations. Sasol invests significantly in capital infrastructure in southern Africa, which results in further employment. Dr Dlamini was not able to provide the exact contribution to GDP. He emphasised that the circumstances of the establishment of Sasol during the apartheid period were very different from its present situation. Sasol is listed on the Johannesburg Stock Exchange and the New York Stock Exchange.

A member of the audience asked how successful NEPAD had been in accelerating renewable energy products.

Ms Chen (NEPAD) responded that the SABF Energy Working Group was considering working with SADC on renewable energy products. The integrated resource plans of SADC member states highlighted the need for innovative energy solutions, particularly in rural areas and in industry. Other units were dealing with regional infrastructure, from concept to bankability. A dedicated desk for investment assists in sourcing funding from commercial banks and other lending institutions.

Ms Olang (NASAC) enquired whether the reason for the scarcity of skills lay with the private sector, which seemed to favour experience over the certification of people.

Dr Dlamini (Sasol) agreed that most organisations emphasise the need for experience. Sasol offers over 300 comprehensive bursaries each year for full-time university studies in engineering, science and commerce. Sasol has also introduced an internship programme where graduates receive work experience. Some of the graduates are retained in the organisation. Big businesses face the challenge that significant growth will come from SMEs. Big companies are generally not expanding, and government therefore needs to look at opportunities to create more SMEs in order to increase employment opportunities.

A member of the audience commented that Sasol is constantly being reprimanded for the negative impact of its wastes on the environment and the health of people in neighbouring areas. Industry must sustain life. What measures is Sasol taking to address negative impacts on the environment and surrounding communities.

Dr Dlamini (Sasol) responded that he was not aware that Sasol was constantly transgressing in terms of its responsibility towards the environment. The company operates under strict regulations laid down by the Department of Water and Sanitation and is regularly audited by the relevant departments to ensure that its operations comply with legislation. The nature of Sasol's business operations do impact on the environment in various ways, but this is within regulations.

Dr Bamwenda (Tanzania Academy of Sciences) remarked that there was some mistrust between the public and private sectors. There are also challenges associated with engagement between foreign investors, and local governments and businesses. He asked how such issues could be addressed.

Ms Chen (NEPAD) responded that whilst there is an element of mistrust between the public and private sectors, it is critical for these sectors to work together. Neutral platforms have been created for engagement between the private sector and government where challenges and issues are raised, for example:

(1) the Southern African Business Forum;

(2) in the pharmaceutical sector, SADC countries have signed a protocol on the registration and labelling of medicines, but national governments still request that the labelling and packaging of medicines be done in different ways. A high-level platform is needed where such issues can be raised;

(3) in the infrastructure sector, where a decision was adopted by SADC Ministers of Transport, following input from the private and public sectors, to address the dualisation of the Beitbridge-Harare-Chirundu highway.

On the issue of engagement between local and international companies, Ms Chen commented that the criteria of national governments for investment would determine the level of engagement. South African legislation requires a certain percentage of local ownership in projects. Countries are increasingly considering such measures in order to develop local talent and economies. In Tanzania for instance, 10% of any deal must go towards local economic development. Investors who build railways, for example, are encouraged to train local engineers and rail operators to manage and maintain infrastructure to take to the next stage of the project. The conditions of any investments need to be clearly defined.

SESSION SIX: DIFFERENT PERSPECTIVES ON SCIENCE BUSINESS INNOVATION – Facilitator: Prof Bernard Slippers, Associate Professor, Forestry and Agricultural Biotechnology Institute, University of Pretoria

The SADC region must act urgently to develop its innovation system. The EU Horizon 2020 framework programme is an example of how this can be achieved.

International Perspectives on Science-Business Linkages: Horizon 2020 – Mr Wolfgang Burtscher, Deputy Director-General, Directorate General Research and Innovation, European Commission

Science business society dialogue is key to ensuring that science exploits its full potential to improve the livelihood of mankind and business. Open innovation and open science must be open to the world.

The EU's International Cooperation in Science, Technology and Innovation: Strategies for a Changing World states that a stronger focus on innovation is needed between academia and industry, and between research and innovation. Horizon 2020 aims to implement an international cooperation strategy on research and innovation. In line with the EU's strategy for international cooperation in research and innovation, Horizon 2020 is open to the participation of researchers from across the world, including Africa. As more research and innovation is performed in international partner countries, it is crucial to be able to access the best researchers and research centres worldwide. Not only does this provide new ideas and expertise, but it also ensures that international researchers are able to collaborate worldwide with the best in the field. Targeted international cooperation activities include addressing societal challenges and enabling industrial technologies.

A key element in the relationship between business and science is the requirement for the approval of projects. Many science academies, businesses and research organisations, governments and society are involved in research projects. This is not an easy process as science and research tend to work in silos, and business is not always aware of the potential of science. Open innovation entails involving many more actors in the innovation process, including researchers, entrepreneurs, users, governments and civil society. These players need to capitalise on the results of international research and innovation to create conducive ecosystems, increase investments, and bring more companies into the knowledge economy.

A key element in the evaluation of research projects under Horizon 2020 is not only the excellence of the research but also its impact in addressing societal challenges. Business must be involved in designing the research to create innovation, new businesses and new governance models. Thirty per cent of participants in Horizon 2020 are from the private sector. In some areas, public-private research partnerships have been created, such as the Clean Sky partnership between the European Commission and the European aeronautics industry that coordinates and funds research activities to deliver significantly quieter and more environmentally friendly aircraft. EU member states assist researchers to learn and gain experience through interaction and involvement in research between the public and private sectors.

Ensuring integrity in science is a complex task that requires high levels of integrity in order to reduce suspicion between researchers and businesses, especially in international markets. Scientists are understandably protective of their reputations and careers, which can be seriously damaged by allegations of misconduct. Scientists therefore generally prefer to put their trust in local arrangements that operate under terms and conditions that they can observe and understand. Universities need to ensure that global innovation realises the potential to strengthen relations between business and science. The Austrian federal government's Strategy for Research, Technology and Innovation, for example, addresses measures to strengthen national research structures with a focus on excellence; to foster the innovative capacity of companies; to allow thematic priority setting; to raise the efficiency of governance; and

to link research, technology and innovation to the education system. The strategy assists in mobilising research, technology and innovation to address the challenges facing society and the economy. It forces scientists to interact with various stakeholders, not only from the research community but also from civil society and business.

The new focus on open science also addresses the issue of open access to research, which favours knowledge transfer to the business sector. The acceleration of knowledge creation and transfer is a key element in improving interaction between science and business. Some research programmes require that students funded through the programme must disseminate their results to the public as early as possible. When results are published in scientific publications, open access to the publication must be ensured. This poses challenges to the private sector, as they are often loath to publish their results. Ethics plays an integral part in research and is a driver for research excellence. All activities funded under Horizon 2020 must comply with ethical principles and relevant national legislation.

In terms of the role of science, business and innovation in Africa, the UN's Agenda 2030 and the associated Addis Ababa Action Agenda fully integrate science, technology and innovation as enablers for socio-economic development and call for increased international cooperation. The AU Agenda 2063 and Europe 2020 have a strong focus on investment in research and innovation for job creation. Through the ten-year Science, Technology and Innovation Strategy for Africa (STISA 2024), the African continent has committed itself to developing innovation-led, knowledge-based economies.

The Roadmap 2014–2017, adopted by African and European Heads of State and Government at the 4th EU–Africa Summit in Brussels, emphasised the vital role of STI in boosting employment, competitiveness, growth and human development, and in addressing pressing societal challenges. A key goal of the roadmap is the development of long-term jointly funded research and innovation partnerships. The joint research agenda focuses on sustainable intensification, agriculture and food systems for nutrition, agricultural trade and markets, and other cross-cutting topics. These issues will be implemented through joint calls under Horizon 2020 and the Pan-African Programme, which provides dedicated support to the Africa–EU Strategic Partnership and is the first EU programme in development and cooperation that covers Africa as a whole. It supports projects with a trans-regional, continental or global added-value in areas of shared interest, and offers new possibilities for the EU and Africa to work together.

An EU-Africa High Level Policy Dialogue on STI between international stakeholders, held in April 2016, addressed the role of science in food security. Apart from scientific research, it is important to have a relevant framework to disseminate knowledge in practical ways.

The European and Developing Countries Clinical Trials Partnership has been implemented in 14 European and 14 African countries and involves the research community, private sector and patients. The objective is to accelerate the development of new or improved drugs, vaccines, microbicides and diagnostics against HIV/AIDS, tuberculosis and malaria as well as other poverty-related and neglected infectious diseases in sub-Saharan Africa.

Under Horizon 2020, the DST, CSIR, Water Research Commission and universities are participating in building a joint European and African research and innovation agenda on waste management for the period 2014–2020. The agenda creates a platform for increased collaborative waste research, sharing of best practice, technology transfer and skills development. The technology can be transferred into African solutions for water treatment systems.

The EU and Africa are equal partners in science, technology and innovation cooperation, working together to tackle common societal challenges in health, food security and climate change. The EU–Africa co-operation will continue to intensify with the development of new partnership schemes. Scientists need to be aware of what is happening in society to ensure increased interaction between civil society, business and science. Research and innovation are crucial to economic prosperity. Measures are needed to ensure that the innovation performances of the partners converge and improve. Expe-

rience shows that when national budgets are constrained by economic crises, disparities in innovation performance become more apparent. Exploiting the potential of the talent pool, and maximising and spreading the benefits of innovation across the region are the best ways of strengthening the region's competitiveness and its ability to address societal challenges in the future.

Discussion

There was a question on whether there were any Horizon 2020 funding instruments co-funded by policy-makers, government and industry that translate research into products and services.

Dr Coussens (Global Young Academy) commented that researchers are encouraged to publish their findings for the sake of public access. She asked what reporting frameworks and tools were used to encourage engagement in society. Research outputs and data provision should be one of the criteria for evaluating researchers' careers and evaluating funding applications.

Mr Burtscher (European Commission) responded that certain parts of Horizon 2020 support inter-disciplinary, cross-country, cross-sectoral projects. With regard to evaluating research careers, research communities and scientists are not necessarily well equipped yet to face new challenges such as skills to manage big data. The Open Science Policy Platform looks at what skills are needed for new scientists and how they can process data from various sources and across different infrastructures through open access to publications.

Dr Baule (Quantum Bio Technologies Lda, Mozambique) commented that there is a large gap in science and collaboration between Europe and Africa. The documenting of projects could be daunting and inhibit publications, or lead to artificial or skewed results being published. Courses are needed to teach students how to apply for funding and manage a project, and to highlight the benefits of collaboration.

Mr Burtscher (European Commission) responded that while participation in the current Framework Programme has been simplified greatly compared to the previous Framework Programme, there is a measure of unavoidable administration involved in the management of inter-disciplinary, cross-country projects involving a diverse range of stakeholders. Generally, the success rate of South Africa in the current Framework Programme is one in five. A requirement for EU research funding in some parts of Horizon 2020 is the involvement of at least three partners from three different countries. Partners should also expose their views by publishing their research. National contacts for participation in EU funding instruments are in place in all African countries, and governments need to assist potential participants.

Youth and Gender Perspective on Science Business Dialogue for Innovation

Dr Fulufhelo Nelwamondo, Executive Director, Modelling and Digital Science Unit, Council for Scientific and Industrial Research (CSIR)

Dr Nelwamondo was born into a rural family where attending school was considered just one of the many chores along with tending cattle and goats. After completing school, he realised there was more to life. His family was proud of his achievement, but they and the community believed that he was selfish to want to leave home to study further. He nevertheless left home and studied to become an electrical engineer.

He became involved in a project on auto-oscillations, which are used to test hearing. He realised that this technology could be used to address various gaps in society, including issues in banking. His thinking was that when a person went to the bank to open a banking account, the person would be requested to put a machine on their ear from which the auto-oscillating signal was picked up. When banks would call the client, there would be no need for them to ask the client for any verification as the auto-oscillation signal would be picked up and sent back to the bank once the client had put his cellular phone to his ear. This technology sparked Dr Nelwamondo's interest in science.

Innovation is one of the many ways to enhance economic growth and create successful nations and regions. There is considerable investment in science and business, but hardly any investment in bridging the gap between the two. This gap is a fruitful area for technology development, and these developing technologies should receive investment.

When people are growing up, they spend time alone which gives them the space to explore, learn, imagine, dream and read. Many successful people have spent a large percentage of their time creating as opposed to consuming; they have built things and started things. Examples of such people include South African-born Elon Musk who became a multimillionaire in his late 20s when he sold his start-up computer company to a larger organisation; Garrett Camp and Travis Kalanick who founded Uber; Steve Jobs and Steve Wozniak who started Apple Computers; and Bill Gates who founded Microsoft.

The participation of youth and gender diversity is crucial in the high-level processes that shape the science agenda and science policies so that the unique perspectives of women scientists and knowledge-holders are incorporated in solutions to the various challenges of advancing sustainable and equitable development. The ways in which students are exposed to science and technology during their formal education influence the way they will interact with technology in the future. It is important for government agencies to identify and promote youth and gender equality in science.

Science is more for the elderly, whereas innovation is more for the young. There is thus an age-gap related to science and business. Investments are predominantly in science rather than in innovations for business. Innovation should not be seen as a process but as the result of a process. Creativity is necessary but not crucial for innovation. Bridging the gap of youth and gender in science requires active development and implementation of policy to ensure the right of youth and women to higher education in order to meet the varying demands of both modern and developing economies.

For many people, 'big data' is a buzzword. If South Africa and other SADC countries want to transform themselves into knowledge economies, one of the main requirements would be developing people and equipping them with skills that meet the constant demands of new technology. Amongst its many programmes, the CSIR runs the Data Science for Impact and Decision Enablement programme with funding from the DST. The programme supports capacity building in the rapidly growing field of data science among recruits from 12 universities across the disciplines of engineering, mathematics, statistics and computer science. The students participate in mentor-guided and learn-by-doing problem-solving related to real-world needs as presented by different stakeholders.

Dr Palesa Sekhejane, Research Specialist, Sustainable Development, Human Sciences Research Council (HSRC)

Trade has improved since 2000, but exports remain low. South Africa, Mauritius and Namibia have the lowest percentage of women participating in labour markets, whilst the highest percentage of participation of both females and males is seen in Tanzania. Throughout SADC, more men than women are employers rather than employees.

SADC countries experience problems of skills and poverty due to the inequalities of their history. Strategies are being developed to address the challenges, including the Regional Indicative Strategic Development Plan (RISDP) and the SADC's STI protocols. These strategies are developed at a high level, however, and the youth (who tend to be at the forefront of innovation) do not participate in dialogues or the framing of strategies. It is therefore important to change the approach to policymaking.

With the SADC region there is little participation in R&D. The region has many advantages, especially in terms of funding through collaboration with international communities. This funding should be used to foster research collaboration within the region.

The results of a survey on South African attitudes towards science show that there has been a decrease in interest in science amongst the young population, and that the region could lose much of its future scientific workforce. It is imperative to encourage interest in science, technology and mathematics. These disciplines are moving at a rapid pace. Whilst many students believe that science and technology make their lives healthier, easier and more comfortable, others believe that science makes their way of life change too fast. Many respondents expressed the belief that science would not necessarily provide them with a good job. Such attitudes discourage young people, particularly women, from participating in the sciences. The survey showed that rural children are less likely to access technologies and less likely to participate in or enjoy the benefits of science, or afford the products of science. It is therefore important for scientists to think about the technologies they promote and how these technologies could be distributed in poor and rural areas.

Attitudes towards sciences are learnt at school. It should be determined whether the level of science learnt at school is relevant or not. Many students study science but never use that knowledge in their careers. Economists need to research why many young people do not follow careers in their field of specialisation. Science education is expensive, and it is disappointing when highly educated scientists are lost along the way. There must be a mind change to encourage youth and women to participate in STI.

An analysis by the AU shows that the SADC region has specialised predominantly in sciences that have less impact and are less specialised. The resources invested in science need to be properly channelled to the more specialised sciences.

South Africa is advantaged through the funding it attracts and through migration. This highlights the need for collaboration to develop the SADC region.

Cultural intelligence is needed to boost collaboration so as to take advantage of the region's resources and knowledge. It is important to make use of alumni opportunities to drive conversations and strengthen collaboration. A system governed by Africans in Africa is needed to provide sustainable funding mechanisms to encourage African scientists at universities and research councils to collaborate on common STI concerns, share expertise and build capacity. Innovation is needed in the education system to encourage young people to enter the sciences, and women need to be affirmed in science and academia.

Discussion

Dr Bulani (ASSAf) referred to Dr Nelwamondo's remarks that his family had thought he was selfish to embark on university studies. In South Africa this is known as 'black tax' and affects many first-generation black university graduates. He asked whether the 'black tax' limits the youth from venturing into business not only in South Africa but elsewhere in Africa. The government often says that it is the responsibility of the youth to create jobs, but government should drive job creation.

Mr Hlahane (Blue-Green Aquaculture) commented that a lack of social mobility was leading to academic erosion. Often a person with a Masters degree is employed, whereas someone with an honours degree could just as easily perform the job. Higher education facilities and institutions such as TIA appear to be failing entrepreneurs as they do not fund them or take too long to disburse the funds, leading to a lack of economic development in countries in the region.

Ms Shaba (Tanzania Association of Non-Governmental Organisations) commented that youth and women carry two-thirds of the world on their shoulders. They are hardly ever consulted when policies are formulated, but when things go wrong it is the women and youth who suffer the consequences and who cushion the impact. Discussions should take this into account and kill the myth that women and youth are afraid of science and need to be encouraged. There are many examples to show that

women and youth are scientists by nature. Women and youth are the custodians of knowledge and skills, whether scientific, artistic or technological. The environment has changed, and women and youth need to document their knowledge in order not to be left with the belief that they have no contribution to make to science and technological development. Women on the home front should be able to carry out research and document their knowledge and furthermore, they should be funded for their research. Science must have a face. Women need to be heard so that the policies that are formulated are applicable to them. It is important to recognise that women and youth are neglected resources. Ms Shaba quoted Margaret Thatcher: "If you want something said, give it to a man; if you want something done, give it to a woman".

Dr Diehl (Leopoldina) asked about the meaning of 'black tax'. Dr Bulani (ASSAf) responded that 'black tax' is the obligation of employed black South Africans to provide for their extended family. 'Black tax' is seen as a duty to subsidise relatives who are less well off. Dr Sekhejane (HSRC) added that 'black tax' is a reality in the lives of most black African youth. Many black Africans are impoverished and do not have time to think about creating other things as they think only about survival. The 'black tax' therefore impairs the enhancement of innovation.

Dr Nelwamondo (CSIR) commented that job creation is not the responsibility of government; it is government's responsibility to create an environment that enables job creation though policies and strategies. The CSIR has sometimes taken technologies through to the market, but the market was not ready to accept them. This shows that it is rarely scientists and engineers who have insufficient training and knowledge, but businesses who do not know the markets well enough. Regarding diversity in innovation, women are generally seen as being risk averse and are therefore perceived to be less innovative. This impacts on how men perceive the role of women in science and highlights the need for policies to be mindful of the rights of women.

Dr Sekhejane (HSRC) responded that science has a human face, but there are problems in the way in which science has been conceptualised. People tend to rely on important technologies and to overlook the benefits that women can bring to science. The WHO states that women in rural areas must be attended by a midwife when giving birth, but rural women are not used to having midwives. They do not have appropriate institutions or access to health professionals and have been assisting one another with childbirth for generations.

Dr Rashamuse (DST) commented that women are often accused of being their own worst enemies by pulling the other down and that this could be seen within the STI realm.

Ms Banda (African Women's Entrepreneurship Programme) commented that much S&T has not been exploited. Scientists come up with research materials but often exclude indigenous knowledge. She cited the example that in some rural areas, dried vegetables are rolled into balls and hung in the kitchen for a period of two years to prevent weevils. Scientists are missing out on opportunities.

A comment was made that the University of Venda is producing a high level of science and scientists. The area has all the elements for developing industry, but this is not recognised. It was suggested that researchers and scientists should create a model village involving women where culture and indigenous systems could be integrated.

Dr Sekhejane (HSRC) concluded that the gender gap in the choice of scientific and technological subjects at both school and tertiary level needs to be addressed by examining the problem at grassroots level. Policymakers should introduce programmes to increase the numbers of women and youth in science.

Dr Nelwamondo (CSIR) concluded that there is a need to develop the youth by attracting the best school learners to science through a unique 'hand holding' experience in order for them to discover science as an exciting, rewarding and fulfilling career.

SESSION SEVEN: CASE STUDIES – Facilitator: Mr Florian Schütz, Senior Research and Innovation Advisor, Fraunhofer Centre for Responsible Research and Innovation (CeRRI), Germany

Rapporteurs reported on the deliberations of the breakout groups.

SMA²RT Foods – Facilitator: Prof Riëtte de Kock, University of Pretoria (UP); Rapporteur: Ms Tinyiko Mushwana (DST)

The University of Pretoria received seed funding from the Southern Africa Network for Biosciences (SANBio) BioFISA II Programme to develop Healthy SMA²RT snacks from the climate-smart crops project. The project aims to develop, manufacture and market healthy SMA²RT food products with traditional values that meet the needs and aspirations of urban-living African millennials; the ultimate aim is to create viable business enterprises. Climate-smart crops such as cow peas, millet, sorghum and marama beans are anticipated to play a greater role in nutrition in the future. The snacks were designed to appeal to the taste of youth of the 21st century. This project is a partnership between the University of Pretoria, the Botswana University of Agriculture and Natural Resources and the National University of Lesotho. Business models have led to start-up businesses that will take the product to the market. Business enterprise development models have been created and a relationship has been built with an established company operating in South Africa and Lesotho to offer value chain management services. Many young people might benefit from the project as it is geared towards targeting graduates. Graduates will be screened to determine their entrepreneurial skills and their potential to start their own businesses.

The breakout group had discussed various contentions and recommendations. The yield potential of the raw materials used for manufacturing the SMA²RT snacks would need to be considered, as would breeding issues related to the types of crops being used. A contentious issue related to the project is that the farmers produce and hand over their product to manufacturers without being fully embedded in the value chain. This results in farmers losing out on potential profits that could be realised towards the end of the value chain. The project needs to bridge the divide between science and business by lobbying for large-scale investment. The long-term sustainability of the products would need to be considered, as health awareness and tastes change over time. The concept of the snacks is unclear: whilst it is able to address to malnutrition, it appeals to a certain type of market such as the modern day youth. It does not appear to be benefiting poorer people.

Regional Connect Platform – Facilitator and Rapporteur: Mr Davis Cook, Research Institute for Innovation and Sustainability (RIIS)

The Regional Connect Platform is the result of a collaborative partnership between the University of Namibia, the Research Institute for Innovation and Sustainability in South Africa, the National Business Technology Centre in Zambia and the Eduardo Mondlane University in Mozambique. The platform aims to connect stakeholders in the private and public sectors, academia and civil society, in order to facilitate and fast-track the exchange of solutions and address business needs. Private organisations, government agencies and non-profit organisations were able to publish challenges that require innovative solutions. The programme ran for only 12 months, but could be revived. A major constraint to the long-term success of the project was concern about the dominant role of South Africa in terms of technology push. The project was managed from South Africa, which was the largest contributor of challenge proposals. Other challenges included the uncertainty of funding to drive the sustainability of the project, and the unwillingness of many firms and organisations to reveal their IP on an open platform, which was exaggerated by South Africa's lack of affiliation to the African Regional Intellectual Property Organisation (ARIPO).

Energy, Mining and Environment – Facilitator and Rapporteur: Prof Frank Winde, North-West University

The group had discussed a project using deep-level mines for energy generation. The basic principle of underground hydropower generation is based on groundwater recharge and harvesting schemes that could be connected through existing shafts or other conduits and utilised for underground hydropower generation. This idea ought to be sold to industry, but industry is inundated with requests for funding of projects and would therefore need to see a winning project in order to secure its buy-in.

SESSION EIGHT: BRIDGING THE GAP BETWEEN SCIENCE BUSINESS SOCIETY IN THE SADC REGION – Facilitator: Dr Audrey Verhaeghe, CEO, Research Institute for Innovation and Sustainability (RIIS)

Panel Discussion: Bridging the Gap between Science Business Society in the SADC Region: What Steps Need to be Taken?

Prof Robin Grimes, Chief Scientific Advisor to the Foreign and Commonwealth Office

Technology readiness levels (TRLs) are a measurement system for assessing the maturity level of a technology. Any technological development can be associated with a TRL between 1 ("We have observed that this happens, but we do not even know why and how it happens") and 9 ("This is used in working real-life applications on the market"). University research in computer science largely falls into TRL 2, 3 and 4, but could mature up to TRL 5 in relatively rare cases. Companies are generally not interested in any technology below TRL 7 or 8, although they may occasionally have departments that operate at TRL 6. The gap that prevents good academic ideas from being picked up by practitioners is referred to as the 'valley of death', where many ideas die. Access to finance and procrastination with respect to IP are the main reasons for an idea ending up in the valley of death. Successful international models, in Germany for example, demonstrate the effectiveness of leading-edge, open-access facilities in driving innovation. The German Fraunhofer System has been adopted in the United Kingdom as the Catapult system. Each sector has a different catapult for addressing the valley of death. The idea is to promote international investment and support of research excellence in order to close the gap between universities and industry through translational infrastructure that provides business-focused capacity and capability to bridge the divide between research and technology commercialisation.

Prof Grimes had worked with Rolls Royce to assist in setting up a university technology centre to embed a particular technology of the company. Mentoring plays a major role in such a process, as people and business need to be convinced, influenced and consulted.

Mr Edwin Bruno, Founder and CEO, Smart Codes, Tanzania

Smart Codes is an award-winning Tanzanian full-service digital agency. The company assists organisations in reaching their target audience through social media, web, mobile and multiple digital devices. It also looks at how science and technology can simplify the work of organisations. The company builds mobile applications that allow employees to access data at any time and from anywhere. It also looks at technology in terms of marketing. Tanzania has seen considerable digital penetration through the internet and smart phones. Clients include banks and insurance companies, which consult with Smart Codes on how they can reach their users through the use of smart phones and the internet.

The M-paper programme is a mobile application newsstand that brings together local newspapers and magazines on the user's mobile device. Partnerships have been formed with companies in Tanzania,

Kenya and South Africa. After downloading the application, selected newspapers or magazines are paid for via M-Pesa or airtime, while people outside the country can pay for the service with their debit or credit cards and access the application using data.

Ultimately business innovation requires fresh ideas. Smart Codes comes up with new ideas to put Africa at the forefront of business, science and innovation through the use of a fully integrated digital service to turn science into business so as to solve African problems.

Mr Barlow Manilal, CEO, Technology Innovation Agency (TIA)

The TIA is an agency of DST. Its primary role is to provide funding and non-funding support to the national system of innovation and to serve as the key institutional intervention to bridge the innovation chasm between R&D from higher education institutions, science councils, public entities and the private sector through to commercialisation.

It is important to understand the journey from science to profit, as neither science nor IP make a profit. IP and science need to be exploited in order to generate an ecosystem of entrepreneurship and profitability. Technology does not stimulate economies. TIA has therefore added business readiness levels (BRLs) and market readiness levels (MRLs) to the TRLs to ensure that enterprises can carry the technologies and markets are able to absorb those technologies.

The TRLs were originally conceived at NASA in 1974 to evaluate the technology readiness of proposed programmes by examining programme concepts, technology requirements and demonstrated technology capabilities. BRLs and MRLs are not as definitive but look at life cycles in terms of enterprise development.

The demand exceeds the resources available to support technology development. The valley of death is therefore a necessary filter to determine whether an innovative idea is marketable or not. Supporting the success of entrepreneurs requires more than financial or physical capital; it requires ensuring that entrepreneurs are equipped for self-supporting, market-ready businesses.

Ms Anneline Morgan, Senior Technical Advisor, Science, Technology and Innovation (STI), SADC Secretariat

The Southern African Development Community was formed to ensure that the region is positioned as a competitor in the global economy. SADC is currently the most stable of the five African regions. The SADC Secretariat is responsible for strategic planning, facilitation, co-ordination and management of SADC programmes. The design of the Secretariat is structured to support the facilitation of member states' policies and programmes so as to contribute to the overall objectives of SADC to achieve regional integration and poverty alleviation.

The overall aim of the development and application of science and technology in the region is to develop and strengthen national policy frameworks and systems of innovation that drive sustained socio-economic development by strengthening regional cooperation, developing and harmonising policies and enhancing intra- and inter-regional cooperation. The pillars for pursuing the agenda of regional integration include industrial development and market integration, and infrastructure support for regional integration. The activities of the Infrastructure and Services Directorate are co-ordinated by six thematic units for energy, tourism, transport, water, climate and communication. The directorate strives to strengthen and sustain national and regional stability, peace and security, as success in these areas will greatly facilitate the attainment of the regions' development goals.

The key thrust of the SADC Industrialisation Strategy is to identify how the economies of the 15 member states can be modernised by using science and technology. The economic benefits expected from

regional integration include increased market size, improved intra-regional trade and investment flows, and increased transfer of technology and experience.

Discussion

Prof Grimes commented that market readiness is essential for the success of any technology or business. Values and attitudes vary between nations. When companies plan to introduce a product or service internationally, they need to ensure that they understand the locality before entering that market.

Mr Bruno (Smart Codes, Tanzania) remarked that entrepreneurs need to develop awareness of the value of their scientific research in order to actively transfer their knowledge to society. They also need to understand the behaviour of the market they intend to enter. Good products lead to businesses, and businesses lead to employment, which ultimately leads to a better society.

Ms Morgan (SADC Secretariat) commented that the public sector should create a favourable environment for policy strategies. Government together with partnerships in the private sector should ensure that human capital is built to ensure the right skills among young people to become the next generation of entrepreneurs. The SADC Industrialisation Strategy addresses the shortage of skills in STEM by assisting with the mobility and movement of people. A recent study assessed the level of implementation of science policies in SADC member states and found low levels of R&D investment as a percentage of GDP. Increased investment is needed in regional infrastructure and research centres. Leadership and accountability at both public and private levels are important in closing the gap between science and business. Skills transfer is essential in order to realise improved quality of life and social well-being.

Prof Grimes commented that the new generation of entrepreneurs need to be educated in the new skills they require to be successful. Entrepreneur mentoring is important. Future entrepreneurs should be willing to fail and taught how to fail gracefully in order to prepare them for possible failure.

Mr Manilal commented that in the South African context there are many more successful stories than negative stories, although society tends to focus more on failure. Americans tend to boast about their innovation and entrepreneurship failures, whereas South Africans and the British are loath to expose their failures. Failure is part of the entrepreneurial learning process; not failing is not the norm. People need to subscribe to the fact that if they fail, they must fail fast, efficiently and elegantly; the art is in knowing when to quit.

Mr Manilal observed that SMEs are generally seen as the answer to youth unemployment. A study in Los Angeles showed that most successful entrepreneurs were aged 37 to 40 years. It should therefore be understood that people graduating from university might not immediately become entrepreneurs and need to gain emotional maturity first. Some people need to face the brutalities of life before becoming successful entrepreneurs.

Dr Diehl (German National Academy of Sciences, Leopoldina) commented that entrepreneurship is often related to culture. Not all cultures accept failure as the norm. One should guard against making the conversation around entrepreneurship failure too complicated. It is important to get the basic conditions right, such as quality education for all children. This would produce a society of educated people from which excellent entrepreneurs would emerge.

Prof Grimes observed that people do not necessarily need to be professionals in order to start a business. They need opportunities to gain practical skills and knowledge in order become successful entrepreneurs.

Mr Lindunda (BongoHive, Zambia) commented that there are innovation hubs across Africa that focus on growth and business start-ups. He was disappointed at the lack of focus on innovation hubs at the

conference. He asked what methods or accelerators were used to bridge the gap between science and business.

Mr Manilal responded that TIA's technology transfer offices at universities support regional innovation hubs in five South African provinces. Innovation hubs are encouraged to liaise with one another, but this is not happening as well as anticipated. More accelerators and incubator hubs need to be developed as key instruments for innovation.

Dr Verhaeghe noted that South Africa has over 200 structures to support entrepreneurship.

Mr Bruno (Smart Codes, Tanzania) noted that he was the product of an accelerated programme. He had started his business during second year at university, and had succeeded by meeting clients and demonstrating the potential product.

Dr Tacheba (Botswana Innovation Hub) commented that most universities in the region do not have an entrepreneurial initiative in their programmes. There are more graduates than jobs available, and there are often shortcomings in the quality of graduates. There are many opportunities but only limited support for entrepreneurs. Universities should ensure that their graduates are well rounded and prepared to enter the market place by providing incubators to enable graduates to develop their ideas for commercialisation.

Ms Olang (NASAC) argued that not all graduates and scientists should become entrepreneurs, and that society needs a balance between science and business.

Mr Bruno (Smart Codes, Tanzania) commented that not all university graduates have the opportunity or ability to run their own business. Different disciplines may be required to make a concept work. Education institutions should address this in order to produce well-rounded graduates.

Dr Verhaeghe commented that there are many techniques and tools available to transfer science and technology to business and society, including tax incentive accelerators, funding mechanisms and competitions. She asked the panel to discuss successful examples.

Prof Grimes responded that different platforms are needed in different areas. There is no single solution for the transfer of science to business and society.

Mr Bruno (Smart Codes, Tanzania) commented that centres of excellence, incubators and hubs are good accelerators, but there is a need to focus on the talents of people in incubation. Most people in incubation require funding or they wish to compete with other entrepreneurs, but there is a need to focus more on the ultimate business.

Ms Morgan (SADC Secretariat) commented that governments have many policies, but implementation is problematic due to weak monitoring and evaluation systems. Other challenges include lack of supervised funding and institutional support. The need for partnerships between government, and business and society is becoming increasingly urgent in order to bridge the gaps between them.

Mr Manilal (TIA) noted that TIA's main focus is technology development, which starts from the proof-of-concept stage and continues to the technology development stage through a seamless progression of technologies along the innovation value chain. Innovators and SMEs need to be able to access risk-adjusted grant funding in quick turnaround times, but funding is not always readily available. In a government entity, approval for R10 million over a six-month period is acceptable, but this is far too slow for an SME. TIA's Seed Funding Project assists innovators at higher education institutions and SMEs to advance their research outputs and ideas to develop prototypes, proof of concept and business cases that could be used for further development.

Dr Verhaeghe noted that society needs to benefit from investments in universities and from the skills that emerge. Policymakers, entrepreneurs, scientists and engineers are equally important and need to be enlightened about the outcomes of research in order to make a difference in society. Scientists transfer knowledge to society, whereas entrepreneurs are the key to innovations.

Dr Verhaege advised the audience that she would be writing a blog on the subject and challenged the forum to document their views on what was needed to bring the various parties together to strengthen one another and close the gap between science, business and society.

SESSION NINE: FOOD, NUTRITION, SECURITY AND SUSTAINABLE AGRICULTURE – Facilitator: Ms Mmampei Chaba, Chief Director: Multilateral and Africa, DST

Market Access and Funding Initiatives in Food and Nutrition Security and Sustainable Agriculture: Sharing Experiences and Lessons Learned – Ms Mmampei Chaba, Chief Director: Multilateral and Africa, DST

The DST had entered in the Research Innovation Network for Europe and Africa (RINEA) made up of partnerships with European partners. RINEA is expected to provide support to the High-Level Policy Dialogue on Science, Technology and Innovation between Africa and Europe as part of the Joint Africa-EU Strategy. It is anticipated RINEA will take up some specific activities as proposed in the draft roadmap for the EU-Africa Research and Innovation Partnership on Food and Nutrition Security and Sustainable Agriculture (FNSSA).

The Roadmap on FNSSA has four priority themes: (1) sustainability intensification; (2) agriculture and food systems for nutrition; (3) expansion and improvement of agricultural trade and markets; and (4) the development of an integrated approach recognising the cross-cutting nature of entrepreneurship, research infrastructures and research and innovation capacity building. Input from business, academia and society is crucial to the successful implementation of this roadmap.

The emphasis of the roadmap is to enhance coordination through policies, programmes and funding mechanisms. It also aims to operate across the entire value chain, from research to ensuring that the technologies and innovation that emanate from research are used by small farmers and end users. Dialogue includes consultation sessions between stakeholders across the innovation chain, the private sector, government research organisations, government partners across Africa and Europe and farmers. Enhanced cooperation is envisaged through continued support for the implementation of the Joint Africa-EU Strategy through a shared common vision, and implementation of joint calls of mutual benefit to both Europe and Africa.

Ms Chaba (DST) posed two questions for debate: (1) the tangible issues that need enhancement through partnerships between the private sector and policymakers in Europe and Africa to address the key elements of the FNSSA Strategy; and (2) the terms and conditions that small actors in the private sector would like to see to make this partnership grow. She invited suggestions on how the DST could assist.

Discussion

The comment was made that the holistic approach of the roadmap would be beneficial in bridging the gap between science, business and society. There was some concern as to whether all-inclusive funding mechanisms would work and whether such mechanisms would be sufficiently flexible to allow opportunities for SMEs.

Ms Chaba (DST) responded that there are a number of instruments mostly funded by the EU that support research, some of which are conceptualised jointly with the private sector. She asked what sort of funding instrument SMEs would require. Current funding instruments were not very flexible. Research agendas were largely predetermined by researchers and passed on to research consortia; they were not necessarily aimed at small businesses. If small business was interested in participating, they would need to consider co-funding.

Mr Hlahane (Blue-Green Aquaculture) commented that new policies were not necessary as there were many current policies that were not being evaluated or implemented efficiently. For example, black economic empowerment (BEE) could be monitored and evaluated for compliance, but this does not happen in the private sector. In the South African agricultural sector, 71% of businesses are still white-owned due to the historical legacy of the country. It is difficult for smaller players to enter the market. Mechanisms are needed to open up the current system in order to create increased value for small farmers and small companies. The equitable distribution of the income of the sector must be monitored and ensured. The speed of government response to enquiries is a key aspect in creating value for SMEs.

Ms Chaba (DST) responded that small business owners face many challenges, most of which are administrative in nature. She asked Mr Hlahane as a small business owner what he would like government to do to address innovation challenges so that his business could benefit.

Mr Hlahane (Blue-Green Aquaculture) responded that his business received no support for importing equipment. The cost of implements is a major stumbling block for smallholder farmers, many of whom cannot afford to buy equipment that would help them move from subsistence farming into semi-commercial agriculture, and from semi-commercial to commercial agriculture. Rent-to-own systems are one way of allowing small businesses access to equipment that they need but cannot afford. This is not a question of government giving implements to smallholder farmers for free, but facilitating the way in which farmers pay for the equipment.

Ms Chaba asked how small businesses would like the DST to support them if they were participating in an EU-African partnership.

A comment was made that research and innovation should be linked using the value chain approach. If the DST were to assist small businesses, they would need to integrate small players in the process of capacity building. Furthermore, funding for innovation cannot be provided without first looking at similar businesses in order to determine the success of similar products. SMEs should be involved throughout the entire value chain process, and innovation approaches in Africa should take into account the recommendations of SMEs.

Ms Chaba (DST) confirmed the request that small businesses and farmers should be involved throughout the value chain in order to add value to the discussions about research solutions to the challenges they face.

There was a comment that farmers and SMEs should be informed about problems such as the shelf-life of their produce and appropriate packaging, as well as research findings on such challenges.

Ms Chaba (DST) responded that a platform would be required for farmers to raise the problems and challenges they face in order for researchers to provide solutions.

Mr Ntho (DST, Lesotho) commented that the speakers had focused on gaining access to equipment as an outcome of technological research, but there are challenges in SMEs and farmers being reached by the research community and vice versa. There is a need for some form of communication between researchers and SMEs, particularly small farmers, in order for research results to be shared.

Mr Masobe (eGoliBIO, South Africa) noted that eGoliBIO runs three incubation programmes through which the needs of farmers are identified. eGoliBIO would like to see a system for encouraging collaboration by bringing together researchers and farmers. Mr Masobe suggested setting up a portal where farmers can pose questions and where responses from researchers and related institutions can be provided. Such a portal would need to provide space for interpretation in the event that a question or response requires clarification.

Mr Hlahane (Blue-Green Aquaculture, South Africa) commented that research councils such as the Agricultural Research Council should ideally be the custodians for teaching and training extension officers, who should advise farmers and inform them of the latest developments in technology. Information is very expensive in South Africa, however. He therefore recommended that regional Departments of Agriculture and extension officers should be the custodians of information dissemination to farmers.

Professor Felix Dakora (Tshwane University of Technology) commented on the need for linkages between research, funding and business. The research focus of small grants that target the needs of the small business sector should be on improving the quality of life in that area and ensuring that there is a market for the product. Academics with a passion for the product and the area should come forward and work with researchers and farmers. This could serve to spark innovation and stimulate small-scale business, which would lead to improved quality of life for local people. Funding schemes should be in place to support small partners, researchers and industrial partners and ensure access to markets so as to improve the well-being of citizens.

Ms Chaba responded that the DST did not have such a system in place but that it could be the start of discussions between the EU and the AU. Funding proposals generally call for a research partner and a private sector partner, but calls for funding had not been directed at farmers. The emphasis had always been on innovation from which products or services would emerge for commercialisation. The involvement of small farmers remained a gap.

Mr Hlahane (Blue-Green Aquaculture) commented that the agri-parks initiative is geared towards agricultural smallholder farmer support and development in 44 districts of South Africa. Government is supposed to buy produce for the food chain directly from farmers involved in this initiative. South Africa has many good policies to address such problems, but there is no evidence that monitoring and evaluation is taking place.

Ms Clauinuka (Agricultural Research Council, South Africa) commented that there had been much discussion on policies and the need to focus on funding instruments. Many innovative ideas were put forward for research by small businesses, but it was big business that had access to information. Access Agriculture is an international NGO that showcases agricultural training videos in local languages that are designed to support sustainable agriculture in developing countries. It also provides a platform for R&D staff in agriculture, service providers, extension agents, communication professionals and representatives of farmer organisations to request videos on new topics or in different languages. Users do not need access to the internet or a smart phone; a very simple cell phone is all that is required. This type of technology would have great potential in the SADC region as it is easy and cheap to access. This highlights the fact that basic research needs to be applied and scaled up.

A participant noted that he had worked on a project in Gauteng funded by the Agricultural Research Council, City of Tshwane, Gauteng Department of Agriculture, National Department of Agriculture, universities in the area and farmers. The project unfortunately did not reach fruition due to problems with financial procurement, especially for the farmers who wanted to supply government. The Public Finance Management Act (PFMA) prohibits research with pre-selected farmers, and therefore a tender process had to be used. The project managed to secure researchers who wanted to be involved, and the departments were willing to fund implements, but the farmers would not sell their food to the proj-

ect due to the financial issues. This is a typical problem facing small-scale farmers who want to sell their produce to government.

Ms Chaba (DST) acknowledged the lack of synergy between the PFMA and many government policies and suggested that this should be raised with government.

A comment was made that the most effective way to generate technology for agriculture is to work with farmers. Many scientists in the region wish to make a difference through direct involvement with farmers. It is therefore crucial for local researchers to work with farmers in order to educate them about new technologies and nutritious smart crops. Funding for technology should be ring-fenced in order to address the problems facing small farmers, assist them to grow crops for commercial gain and play a role in alleviating poverty in the region. A special grant scheme should be developed to address this.

Ms Chaba (DST) noted that innovative ways need to be found to encourage big business to become involved in dialogue and listen to the topics of discussion raised by science, business and society.

Linking of Smallholders Farmers to Market – Dr Nomsa Dlamini, Research Scientist, Food Sciences and Technology, CSIR

The CSIR and Botswana had developed a nutritious product based on indigenous plants that addresses the challenges of malnutrition. This product was funded by the Southern Africa Network for Biosciences (SanBIO) FISA11 and is marketed in Botswana and South Africa. The entire production chain encourages communities to grow nutritious crops, thereby creating employment opportunities. The challenges in maintaining a sustainable supply of the product include the rising costs of technology and the lack of education in agricultural land management. Sometimes the quantities of crops are too small to share, which hinders research and commercialisation. This gap between research and commercialisation needs to be addressed. Research facilities are subject to regulations when products are geared towards commercial production. The CSIR is currently working with Botswana, which has similar state-of-the-art research facilities. Due to the lack of funding, working with Zimbabwe is not yet a possibility. Funding is essential for undertaking research, and the buy-in of private and public partnerships is therefore essential in order to realise a marketable product.

Some financial institutions have made inappropriate financial instruments available to subsistence farmers who do not have the means for repayment. Without finance from either the public or the private sector, there is little hope of building a commercially sustainable smallholder sector in the region. Governments need to look at innovative ways to unlock finance for smallholder farmers who wish to move into more commercially oriented farming opportunities. Creative ways of reducing the risks associated with financing smallholder farmers – such as guarantee options, the blending of government or donor grants with commercial loans, insurance measures, group schemes and tax incentives – need to be fully explored as options to increase the flow of finance. These measures should be accompanied by farmer support services to improve the business acumen of farmers, and their skills in production and marketing.

Concern was expressed that SMEs cannot afford to build state-of-the-art research centres. Would organisations such as TIA be prepared to take the risk of producing products to test the market?

The comment was made that big business would make substantial changes to their facilities for a single product that had not yet been proven. Researchers would need to work with small business from the outset in order for them to build the required facilities to manufacture and commercialise their products. To improve the bargaining power of farmers and create opportunities to add value, it is becoming increasingly important to form partnerships and long-standing relationships of trust between role players.

Ms Morgan (SADC Secretariat) commented that a regional network is needed to create and strengthen linkages with the agricultural sector in SADC, which features prominently in the regional economy.

The need for macro-economic and sectoral policy convergence and harmonisation has been recognised as a prerequisite for accelerated shared growth and regional economic integration. Various platforms to address this are in place, including the Farmers' Union, the Regional Agricultural Policy and the Regional Agricultural Investment Bank. The Industrial Relations Strategy acknowledges that an integrated regional market is critical to generating the economies of scale needed to unlock the region's industrial potential and enhance the competitiveness of domestic firms. In this context, the promotion of regional and global value chains and production network linkages across borders has the potential to stimulate efficiency gains through integrated regional markets built on comparative and competitive advantages.

Dr Dlamini (CSIR) noted that the new Maggi Two Minute Noodles with real Morogo was the result of public-private collaboration between Nestlé South Africa, the CSIR, ARC, University of Fort Hare and DST. CSIR, Nestlé and its partners researched amaranthus, a species of morogo, and worked closely with farmers to perfect their cultivation and refine the plants into a powder that preserved their nutritional benefits. In this project, the challenges of small business were taken care of in terms of research and processing facilities, funding, policies and regulations. It is a good example of what can be achieved if private and public companies work together and invest in infrastructure. Governments must acknowledge the importance of small farmers and small businesses for agricultural sustainability.

Linking of Smallholder Farmers to Market: The Role of the National Agricultural Marketing Council – Mr Victor Mmbengwa, NAMC

The National Agricultural Marketing Council (NAMC) was formed after the demise of the Agricultural Board, which played an important role in marketing and trade in agriculture. NAMC was formed to facilitate the linking of smallholder farmers and support commercial farmers on whom the country depends for food security.

One of the major reasons for the failure of farming SMEs is lack of capacity in running farming as a business. SMEs need capacity, market accessibility, business management skills, effective extension services, adequate support programmes and adequate finances.

NAMC assists farmers with strategic issues. The participation of small-scale farmers, their contribution to the production of high-value food commodities and their links to markets have shown that whilst institutions, such as cooperatives, contract farming and growers' associations, do not completely ignore small-scale farmers, some policy support is imperative to strengthen their linkages with markets. The Agricultural Trust was established to manage and coordinate communication between government and the agricultural sector. Agribusiness Development Schemes were designed and implemented to uplift smallholder farmers and encourage their integration into the commercial mainstream. The Market and Economic Research Centre gauges the efficiency of the market for agricultural commodities, devises programmes to improve the performance of the market, and initiatives and guides market development programmes. NAMC supports capacity building through collaboration with universities, sector education and training authorities, provincial departments and the Agricultural Research Council to assist students with funding and research opportunities in smallholder and commercial farming.

NAMC recognises the need to focus on secondary activities in agriculture such as the role of the value chain. Government and other commercial entities tend to support the commercial agricultural sector, while poorer smallholder farmer are left behind. The concept of the participatory value chain is a key factor in defining and formulating agricultural development interventions such as processed foods and food products based on readily available staple food with the potential to substitute food imports and improve national food security. Value chain programmes facilitate and support producer organisations, allowing economies of scale in buying inputs and selling products. Improved business services to small-scale farmers and agribusiness help to improve quality and efficiency by reducing costs and expanding

operations. It is important that governments anticipate future vulnerabilities and build the capacities of participants to innovate, diversify or exit as markets change.

Through the National Red Meat Development Programme, farmers are able to take their livestock to facilities for feeding and veterinary services until they are ready for the market. The programme was established to ensure that smallholder farmer stock is improved so that they can participate actively in the formal red meat market.

NAMC's mentorship programme has achieved positive results in increasing the cash-flow of smallholder farmers and their knowledge and understanding of how markets work.

Conference Summary – Prof Jutta Schnitzer-Ungefug, Secretary-General, Leopoldina

Prof Schnitzer-Ungefug referred to the quotation "the curtain is closed but all the questions are still open". There had been much discussion and debate over the last two days, but many questions had not been discussed or were left unanswered.

The conference had heard how countries outside the region had benefited economically from strengthening their science community. One of the best ways to maintain economic surplus is to invest in society by strengthening education to enhance scientific research. Strong science communities and strong businesses complement each other and are crucial to the wellbeing of all members of society.

Prof Schnitzer-Ungefug commented that it was a pity that there had not been more business representatives and entrepreneurs attending the conference. Science academies produce science-based recommendations, which are often recommended to policymakers for legislation and implementation. Conferences such as this are therefore extremely helpful in fostering more direct exchange between science, business and society.

The conference had been well attended, and the deliberations had been very successful. Prof Schnitzer-Ungefug thanked participants for their engagement in the dialogue and expressed the hope that such interactions would continue in future. On behalf of her colleagues from Leopoldina, Prof Schnitzer-Ungefug thanked members of ASSAf (particularly Prof Roseanne Diab, Dr Siyavuya Bulani and Mr Stanley Maphosa) and Leopoldina (especially Ms Bonny Brandenburger and Dr Christiane Diehl) for their contribution to organising the conference. She thanked the funders of the conference namely the DST and the Federal Ministry of Education and Research in Germany. In conclusion, she thanked the participants for attending the conference and wished everyone a safe trip home.

Official Close of Conference and Departure – Dr Siyavuya Bulani (ASSAf)

In closing the conference, Dr Bulani thanked everyone for their attendance. He noted that the conference had been attended by delegates from different African countries and that SADC had been particularly well represented.

ANNEXURE A: LIST OF ACRONYMS

AIDS	Acquired immune deficiency syndrome
ARC	Agricultural Research Council
ARIPO	African Regional Intellectual Property Organisation
ASSAf	Academy of Science of South Africa
AU	African Union
AWEP	African Women's Entrepreneurship Programme
BBAW	Berlin-Brandenburg Academy of Sciences and Humanities
BEE	Black economic empowerment
BMBF	German Federal Ministry of Education and Research
BRL	Business readiness level
CEO	Chief Executive Officer
CeRRI	Centre for Responsible Research and Innovation
CSI	Corporate social investment
CSIR	Council for Scientific and Industrial Research
DST	Department of Science and Technology
EASAC	European Academies' Science Advisory Council
EU	European Commission
FDI	Foreign directive investment
FNSSA	Food and Nutrition Security and Sustainable Agriculture
GDP	Gross domestic product
GloSYS	Global State of Young Scientists
GYA	Global Young Academy
HIV	Human immunovirus
HSRC	Human Sciences Research Council
HVDC	High voltage direct current
IAP	InterAcademy Partnership
ICSU	International Council for Science
ICT	Information and communication technology
IP	Intellectual property
IPR	Intellectual property rights
IT	Information technology
MRL	Market readiness level
NAMC	National Agricultural Marketing Council
NASAC	Network of African Science Academies
NEPAD	New Partnership for Africa's Development
NIPMO	National Intellectual Property Management Office
NRF	National Research Foundation
OEM	Original equipment manufacturing
PFMA	Public Finance Management Act
R&D	Research and development
RINEA	Research Innovation Network for Europe and Africa
RISDP	Regional Indicative Strategic Development Plan
RISS	Research Institute for Innovation and Sustainability
S&T	Science and technology
SABF	Southern African Business Forum
SADC	Southern African Development Community
SANBio	Southern Africa Network for Biosciences

SET	Science, engineering and technology
SMEs	Small and medium enterprises
STEM	Science, technology, engineering and mathematics
STEMI	Science, technology, engineering, mathematics and innovation
STI	Science, technology and innovatio
STISA	Science, Technology and Innovation Strategy for Africa
the dti	Department of Trade and Industry
THRIP	Technology and Human Resources for Industry Programme
TIA	Technology Innovation Agency
TRL	Technology readiness level
TWAS	The World Academy of Sciences
UCT	University of Cape Town
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UP	University of Pretoria
Wits	University of the Witwatersrand
WTO	World Trade Organisation

ANNEXURE B: LIST OF ATTENDEES

Dr Siyavuya Bulani	Academy of Science of South Africa
Prof Roseanne Diab	Academy of Science of South Africa
Ms Nozuko Hlwatika	Academy of Science of South Africa
Ms Marvin Mandiwana	Academy of Science of South Africa
Mr Stanley Maphosa	Academy of Science of South Africa
Ms Henriette Wagener	Academy of Science of South Africa
Prof Himla Soodyall	Academy of Science of South Africa
Mr Obakeng Maema	Agri-Biotech Sector, Technology Innovation Agency
Dr Maletsema Alina Mofokeng	Agricultural Research Council-Grain Crops Institute
Dr Pedaella Clauinuka	Agricultural Research Council-Grain Crops Institute
Mr Barry Nkomo	Bakgatla Ba Kgafela Investment Holdings Company and Independent Consultant (BNHD Consulting CC)
Ms Brigitte Dwagh	BEKPO
Mr Abisai Mafa	BioSafety Board of Zimbabwe
Mr Pule Hlahane	Blue-Green Aquaculture
Mr Lukonga Lindunda	BongoHive
Dr Budzanani Tacheba	Botswana Innovation Hub
Ms Lesego Moribame	Botswana Institute for Technology, Research and Innovation
Mr Abiola Ezekiel Taiwo	Cape Peninsula University of Technology
Mr Pat Mmope	Coblex Investment
Dr Isabel Kazanga	College of Medicine, University of Malawi
Ms Ravini Moodley	Council for Scientific and Industrial Research (CSIR) - Licensing and Ventures
Dr Fulufhelo Nelwamondo	Council for Scientific and Industrial Research (CSIR)
Ms Ravini Moodley	Council for Scientific and Industrial Research (CSIR)
Dr Nomsa Dlamini	Council for Scientific and Industrial Research (CSIR)
Ms Busiso Mavankeni	Crop Breeding Institute
Ms Mwanaisha Mkangara	Dar es Salaam Institute of Technology, Tanzania
Mr Stefan Haffner	Federal Ministry of Education and Research, International Bureau Germany
Mr Nathala Mokhele	Department of Agriculture, Forestry and Fisheries, South Africa
Ms Boitumelo Sekhute-Batungamile	Department of Research Science and Technology, Botswana
Mr Patrick Mphadzula	Department of Science and Technology, Malawi
Dr Konanani Rashamuse	Department of Science and Technology, South Africa
Ms Mmampei Chaba	Department of Science and Technology, South Africa
Ms Refilwe Mashigo	Department of Science and Technology, South Africa
Ms Neo Mofokeng	Department of Science and Technology, South Africa
Ms Tinyiko Mushwana	Department of Science and Technology, South Africa
Ms Sikhonzile Sihkosang	Department of Science and Technology, South Africa
Dr Isavani Maioice	Department of Science and Technology, South Africa

Ms Vinny Pillay	Department of Science and Technology, South Africa
Mr Tsepo Ntho	Department of Science and Technology, Lesotho
Ms Puseletso Thubela	Department of Science and Technology, Lesotho
Mr Bakue Nizibone	Department of Trade and Industry, South Africa
Ms Nkuli Shinga	Department of Trade and Industry, South Africa
Ms Izibele-Nizibone Sakwe	Department of Trade and industry, South Africa
Mr Wolfgang Burtscher	Directorate-General Research and Innovation, European Commission
Ms Rofahki Okasana	DLR-PL
Mr Kenny Masobe	eGoliBio
Mr Richard Mponda	EOH Health
Ms Kammy Young	Eskom Holdings
Dr Brinda Ramasawmy	Faculty of Agriculture, University of Mauritius
Prof Voster Muchenje	Fort Hare University
Mr Florian Schütz	Fraunhofer Center for Responsible Research and Innovation
Ms Bonny Brandenburger	German National Academy of Sciences, Leopoldina
Prof Jutta Schnitzer-Ungefug	German National Academy of Sciences, Leopoldina
Dr Anna Coussens	Global Young Academy
Ms Shadi Puoane	Government Communication and Information System
Mr Christof Runde	IMS International
Prof David Romero	IMS International
Mr Jay Murinani	Innpmer
Ms Ana Lidia Gungulo	Institute of Agricultural Research of Mozambique (IIAM)
Prof Volker ter Meulen	German National Academy of Sciences, Leopoldina
Dr Christiane Diehl	German National Academy of Science, Leopoldina
Ms Tabitha Nindi	Malawi University of Science and Technology
Mr Joseph Issa	Malawi University of Science and Technology Industrial Research Centre
Mr Vishnu Borappa	Metal SA
Mr Leon Ebapani	Ministry for Scientific Research and Technology, Congo
Mr Nyasha Masungo	Ministry of Higher and Tertiary Education, Science and Technology Ministry
Mr Sikelela Fanana Dlamini	Ministry of Information, Communication and Technology, Swaziland
Ms Bethusile Rejoice Maseko	Ministry of Information, Communication and Technology, Swaziland
Mr Nqoba Msibi	Ministry of Information, Communication and Technology, Swaziland
Dr Domingos da Silva Neto	Ministry of Science and Technology, Angola
Ms Eli Mokotong	National Industrial chamber
Ms Verna Leon	National Institute of Science, Technology and Innovation (NISTI)
Mr Bwalya Katati	National Institute of Scientific and Industrial Research (NISIR)

Dr Kerry Faul	National Intellectual Property Management Office
Mr Nyongombe Ekambo Gayi	National Pedagogical University
Mr Victor Mmbengwa	National Agricultural Marketing Council
Dr Gansen Pillay	National Research Foundation
Dr Makobetsa Khati	National Research Foundation (NRF)
Mr Filipo Zulu	National Science and Technology Council (NSTC)
Dr Luis Miguel Gabriel	National Technological Centre (CTN), Angola
Mr Innocent Mandona	National Technology Business Centre; The Southern Africa Innovation Support (SAIS) programme
Prof Molibeli Taele	National University of Lesotho
Ms Lynette Chen	NEPAD Business Foundation
Ms Jackie Olang	Network of African Science Academies
Prof Barney Pityana	Network of African Science Academies
Prof Frank Winde	North-West University, Potchefstroom, South Africa
Mr Patrick Newton Bondo	Outreach Social Care Project
Ms Sylvia Chabala Banda	African Women's Entrepreneurship Programme (AWEP)
Mr Sivuyise Ndzendze	Eskom
Dr Claudia Baule	Quantum BioTechnologies Lda
Mr Rafael Nkateko Khoza	RAPX Engineering (Pty) Ltd
Mr Francis Chimutengeza	Ministry of Higher and Tertiary Education, Science and Technology Development
Mr Davis Cook	Research Institute for Innovation and Sustainability (RIIS)
Dr Audrey Verhaeghe	Research Institute for Innovation and Sustainability (RIIS)
Dr Palesa Sekhejane	Human Science Research Council
Ms Anneline Morgan	SADC
Ms Thirumeni Naidoo-Swettenham	SANBio-BioFISA II Programme
Ms Marja-Reetta Paaso	SANBio-BioFISA II Programme
Ms Zvikomborero Tangawimira	SANBio-BioFISA II Programme
Dr Jose Jackson-Malete	Southern African Research and Innovation Management Association (SARIMA)
Ms Dipalesa Mpye	Southern African Research and Innovation Management Association SARIMA
Dr Thulani Dlamini	Sasol
Mr Edwin Bruno	Smart Codes
Mr Imraan Patel	South African Department of Science and Technology
Ms Rizwana Mia	South African Medical Research Council
Ms Denise Lundall	South African National Energy Development Institute (SANEDI)
Mr Jamo Macanze	Southern Africa Innovation Support (SAIS) programme
Dr Nelius Boshoff	Stellenbosch University
Prof Keto Mshigeni	Tanzania Academy of Sciences

Dr Gratian Bamwenda	Tanzania Academy of Sciences
Ms Marie Shaba	Tanzania Association of Non-Governmental Organisations
Mr Barlow Manilal	Technology Innovation Agency
Mr Teboho Seseng	Technology Innovation Agency
Prof Alinah Segobye	TMACI
Dr Kunaadan Aryela	UG
Prof Robin Grimes	United Kingdom Foreign and Commonwealth Office
Prof Francis Petersen	University of Cape Town
Prof Bernard Slippers	University of Pretoria
Prof Stephanie Burton	University of Pretoria
Prof Riëtte de Kock	University of Pretoria
Mr Matthew Melcolm	Vow FM
Ms Marilyn Collins	Write Connection

Edwin Bruno

is an award winning software engineer and entrepreneur. He is the founder and Chief Executive Officer of Smart Codes (T) Limited, a digital agency based in Dar es Salaam, Tanzania.

Stephanie Burton

is the Vice-Principal responsible for research and postgraduate education at the University of Pretoria (UP).

Anna Coussens

is a member of the Global Young Academy (GYA) and the Southern Africa Champion for the Global State of Young Scientists (GloSYS) Africa project

Kammy Dhaver-Young

heads Innovation Research and Management at Eskom.

Thulani Dlamini

is Vice President: Strategic R&T and CIBI at Sasol. He is a member of ASSAf.

Siyavuya Bulani

is the Senior Liaison Officer at ASSAf and is in charge of the Academy's Overseas Collaborations sub-program.

Davis Cook

is the Chief Executive Officer of the Research Institute for Innovation and Sustainability (RIIS).

Roseanne Diab

is Executive Officer of ASSAf and Professor Emeritus in the School of Environmental Sciences, University of KwaZulu-Natal.

Christiane Diehl

is Deputy Head of International Relations at the German National Academy of Sciences Leopoldina. She is the Executive Director of the network of European Science Academie (EASAC).

Nyameko Barney Pityana

was the Rector of the College of the Transfiguration, Grahamstown. He is the former Principal and Vice-Chancellor of the University of South Africa (Unisa).

Kerry Faul

is the Head of the National Intellectual Property Management Office (NIPMO), a specialised service delivery unit within the Department of Science and Technology.

Walter Lindner

is the German Ambassador in South Africa.

Stanley Maphosa

is the International Liaison Manager of ASSAf.

Voster Muchenje

is a Research Professor at the University of Fort Hare and the Editor-In-Chief of the South African Journal of Animal Science. He is a Member of ASSAf.

Fulufhelo Nelwamondo

is Executive Director of CSIR Modelling and Digital Science (MDS).

Robin Grimes

is the Foreign Office's Chief Scientific Adviser (CSA) and is responsible for providing advice to the Foreign Secretary, Ministers and officials on science, technology and innovation.

Barlow Manilal

is Chief Executive Officer of the Technology Innovation Agency (TIA).

Anneline Morgan

is seconded to the SADC Secretariat as the Senior Technical Advisor: Science, Technology and Innovation.

Imraan Patel

is Deputy Director-General at the Department of Science and Technology.

Daan du Toit

is Deputy Director-General for International Cooperation and Resources in the South African Department of Science and Technology, responsible for all aspects of South Africa's international science, technology and innovation partnerships.

Florian Schütz

is Senior Research and Innovation Advisor at Fraunhofer Center for Responsible Research and Innovation.

Audrey Elizabeth Verhaeghe

is Chairman of Research Institute for Innovation and Sustainability (RIIS), Chairman of The SA Innovation Summit and championed the SA Innovation Network (Saine).

Himla Soodyall

is the Director of the MRC/NHLS/Wits Human Genomic Diversity and Disease Research Unit at the National Health Laboratory Service and University of the Witwatersrand.

Francis Petersen

is Deputy Vice-Chancellor of the University of Cape Town.

Jutta Schnitzer-Ungefug

serves as Leopoldina's Secretary-General.

Bernhard Slippers

is a Professor in Genetics at the University of Pretoria (UP).

Volker ter Meulen

was Chairman of the Institute of Virology, University of Würzburg, and Dean of the Faculty of Medicine. Ter Meulen was President of the German Academy of Sciences Leopoldina. In 2013 he was elected co- chair of IAP and re-elected in 2016.

Frank Wilde

is a professor at the Vaal Campus of the North-West University and is Chair of the IGU Commission for Water Sustainability.

Wolfgang Burtscher

is Deputy Director-General of the European Commission's Directorate-General for Research and Innovation, responsible for Open Innovation, Open Science, Open to the World.

Palesa Sekhejane

is research specialist on sustainable development in the department of African Institute of South Africa (AISA) at the Human Science Research Council.

SADC — Southern African Development Community — Towards a Common Future

Network of African Science Academies — NASAC

Global Young Academy

European Academies Science Advisory Council — easac