BRICS Academies Forum 2023

Proceedings Report of Sessions 2 and 3
2 December 2023

Pretoria, Maslow Times Hotel, Menlyn

Inter-Academy Collaboration on the Global Polycrisis

February 2023

DOI http://dx.doi.org/10.17159/assaf.2024/96

Cite: BRICS Academies Forum 2023 Proceedings of Sessions 2 and 3 on 3 December 2023 DOI http://dx.doi.org/10.17159/assaf.2024/96

Published by: Academy of Science of South Africa (ASSAf)

PO Box 72135, Lynnwood Ridge, Pretoria, South Africa, 0040

Tel: +27 12 349 6600 • Fax: +27 86 576 9520

E-mail: admin@assaf.org.za

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 based on 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 (No 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

BRICS Academies Forum 2023 Proceedings of Sessions 2 and 3 - 2 December 2023

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.

TABLE OF CONTENTS

INTRODUCTION

The Academy of Science of South Africa (ASSAf) and the Department of Science and Innovation (DSI) jointly hosted the 2023 BRICS Academies Forum on 1-2 December 2023 in Pretoria, South Africa. The Forum is the body of science academies of the BRICS member states including the: Brazilian Academy of Sciences (ABC), Russian Academy of Sciences (RAS), Indian National Science Academy (INSA), Chinese Academy of Sciences (CAS), and ASSAf. The theme of the 2023 BRICS Academies Forum Meeting was "Inter-Academy Collaboration on Global Crises" which was aligned to the 2023 BRICS Science, Technology, and Innovation (STI) theme; "Building BRICS and Africa Partnership for Mutually Accelerated Growth, Sustainable Development and Inclusive Multilateralism."

The delegations of the BRICS Academies were welcomed by ASSAf Acting President, Prof Stephanie Burton, and DSI Deputy Director-General for International Cooperation and Resources, Mr Daan du Toit during the Opening and Welcome Dinner ceremony on the 1st of December. At the Welcome Dinner welcome remarks were received from RAS, INSA, CAS, and ASSAf, unfortunately ABC could not attend. Dr Rasigan Maharajh, ASSAf member gave a keynote address titled, ''Global Polycrisis and the BRICS Academies of Sciences.'' He presented some of the defining characteristics of polycrisis and explored the implications of the Academies of Sciences from Brazil, Russia, India, China, and South Africa (BRICS). Day 2 of the meeting was dedicated to technical presentations by each Academy and subsequent discussions. Prof Burton directed the proceedings in session 2 and Prof Himla Soodyall the ASSAf Executive Officer moderated the discussion in session 3.

SESSION 2 (CHAIR: PROF STEPHANIE BURTON, ACTING PRESIDENT, ASSAf)

OPENING AND WELCOME

Prof Stephanie Burton opened the meeting and welcomed everyone. The theme of polycrisis had been adopted as the overall theme for the BRICS Academies Forum, bringing together the various contributory factors in an interdisciplinary way.

TECHNICAL PRESENTATIONS

Russian Academy of Sciences

Facing the global polycrisis: Scientific infrastructure and break-through research directions in Russia (Prof Nikolaevich Stepan Kalmykov, Vice-President, RAS)

The presentation would focus on the role of the Russian Academy of Sciences (RAS) in terms of research infrastructure in Russia. The current president of RAS had been elected just over a year ago in September 2022, and the new vice-presidents (one of whom was Prof Kalmykov) had started their terms around the same time. Prof Kalmykov a chemist by training and previously worked at the Lomonosov Moscow State University, where he still held a half-time position as a professor of Nuclear Chemistry.

RAS was responsible for all scientific expertise related to state funding for research, with about 20 000 projects to be expedited per year, involving the expertise of approximately 50 000 people since at least two people were involved per project. Prof Kalmykov expressed his firm belief that scientific-based action and education were the only way to face the polycrisis and minimise the consequences.

The RAS was established by Peter the Great in 1724 and would be celebrating its 300th anniversary in 2024 with a programme of scientific and public events. The academy had 680 full member academicians and 1 113 corresponding members. The academy was divided into the following 13 branches, covering all aspects of modern science: mathematics; physics; nanotechnologies and information technologies; energetics, machinery, mechanics and management systems; chemistry and material research; biology; physiology; earth sciences; social sciences; global processes and international relations; history and philology; medicine; and agriculture. Each branch has its own head, and the vice-presidents are responsible for working with the branches. Prof Kalmykov, for example, at the time was the vice-president responsible for chemistry and biology.

The offices of the president and vice-presidents are housed in an Academy building dating back to 1756, which is now a national heritage site. The more recent building was constructed in the 1980s. The original building in which the St Petersburg Academy of Sciences was established is now a museum of history.

The national research infrastructure under the supervision of the RAS is divided across a number of different institutes and universities:

- 10 federal universities, plus Moscow State University and St Petersburg State University, which do not fall under the Ministry of Education (unlike other universities in Russia) but belong directly to the government and have separate budgets. These two universities are permitted to develop their own education curriculum that is not linked to the Ministry
- 29 national research universities located across the country
- 45 state research centres
- 2 national research centres, one of which is the Kurchatov Institute, while the other deals with aerospace exploration research.

While the infrastructure is located throughout the country, it tends to be clustered in the large cities including Moscow, St Petersburg, Yekaterinburg, Novosibirsk and others.

Some prior research directions in the projects that the RAS was supervising and expediting that were pertinent to the theme of addressing the global polycrisis included: gene biology, new materials (including composites, biomaterials, new polymers), environment and ecology, pharmacy (including resistance to medical treatment; it is forecast that by 2023 there will be more deaths due to microbial resistance than from cancer), new chemical processes, microelectronics, energy research, cognitive research, Artificial Intelligence (AI) and supercomputer calculations, social sciences, and economy forecasts.

The megascience infrastructure is especially important. These are large-scale facilities that are not constructed for a single institute or university, but can be accessed by researchers from across the country as well as internationally to conduct research for periods ranging from several days to several weeks; for example, synchrotrons, research reactors, observatories, supercomputer facilities and others. Breakthroughs in science related to solving the global polycrisis require megascience facilities.

The federal programme has large-scale megascience infrastructure distributed throughout the huge territory of Russia. The Kurchatov complex of synchrotron-neutron investigations is situated north-west of Moscow, not far from the city centre, in Shchukino district.

The fully state-funded SKIF (Siberian circle source of photons) synchrotron is under construction and is due to be launched in 2025. This fourth-generation synchrotron will be available to analyse samples with a high level of brightness. The decision was taken to build this synchrotron near Novosibirsk because many of the users would come from the RAS institutes located in that city (e.g. the Institute of Catalysis, oil chemical institutes, nuclear physics institutes). In the first phase, six stations are being constructed, and 13 stations will be constructed in the second phase that can be used for investigations of materials including biomolecules, new materials and analytic processes, biochemistry, heritage, environment and many others.

The synchrotron is a very intense source of X-ray photons that can be used to study and develop electronics and microelectronics, geological samples, environmental science, pharmaceuticals and medicine, new molecules to examine the structure of various biomolecules, the structure of biology, chemistry, and the analysis of historical heritage samples. The information that can be derived using the synchrotron includes the chemical-element composition and tomography of a sample without dissolution or damaging it. This type of investigation is important in many fields of science including biomedicine and the environment.

Prof Kalmykov referred to the example of a project in which he was involved in nuclear heritage related to the spread of nuclear contamination. Several large nuclear facilities dating back to the 1950s and 1960s have to be decommissioned. It is an important and challenging scientific task to do this cheaply and effectively, with as little environmental impact as possible.

Plutonium is part of the nuclear heritage. This element is known as the 'element of surprise' due to its complex chemistry, with at least four different observational states, each with entirely different chemical behaviours and properties of the oxidation state. It is essential to establish a fundamental knowledge of this element and its behaviours under different environmental conditions, and what technologies can be used to clean up the environment safely and effectively.

A paper on the spread of plutonium contamination was published in *Nature* in 1999, and a paper in which Prof Kalmykov was involved was published in 2006. The large-scale Mayak facility that was responsible for plutonium production is now a commercial plant for re-processing spent nuclear fuel. Large territories are contaminated, and environmental protection at the site is of the utmost importance to stop migration especially to rivers. Such knowledge can be acquired only from a basic understanding of the behaviour of plutonium under different environmental conditions. Synchrotrons are used for this purpose, as they provide a range of different methods, including characterisation of environmental samples from different perspectives and using a variety of methods (chemical composition, tomography, microscopy). Only large-scale facilities such as synchrotrons can be used for the overall characterisation of different contaminated samples. By analysing the samples, it is possible to learn about the structure and chemical speciation of plutonium and develop effective methods to clean the samples and create barriers to stop the radioactive migration. Many papers have been published in top journals on the characterisation of different plutonium-contaminated samples using synchrotrons, high-resolution microscopy and other methods.

Another megascience facility is the Multi-Purpose Fast Research Reactor (MBIR), an experimental multipurpose high-flux fast neutron reactor being built at Dimitrovgrad and sponsored by the State Atomic Energy Corporation, ROSATOM, which is the central holding company for Russia's entire nuclear energy complex. MBIR is intended to be an internationally open facility that can be accessed by researchers from different countries. MBIR is a multipurpose fast-neutron research reactor with capacity of 150 MWt and maximum neutron flux density of $5.3*10^{15}$ n/cm^{2}s. The facility will have vertical and horizontal channels for many purposes and will allow scientific studies in a number of areas including:

- Testing of advanced structural and absorbing materials in support of the development of Generation IV technologies

- Research into advanced fuel, fuel elements and technologies for closing the nuclear fuel cycle
- Production of isotopes and raw materials for radiopharmaceuticals, as well as the development of modified materials
- Research with the use of neutron beams in the fields of medicine, and fundamental and applied physics.

Construction is due to be completed in 2024. The reactor core had already been installed; pre-launch tests would begin in 2024, and the facility will be launched in 2025/26. It was hoped that scientists from BRICS would use the facility. MBIR will have experimental capabilities to support the following kinds of research:

- Basic research: ultracold neutrons; boron neutron capture therapy for cancer
- Isotope production for medical applications
- Safety studies: process modelling; transient and abnormal conditions; verification of computer codes
- Testing of new equipment and engineering design configurations (e.g. testing coolants for new-type proto-reactors)
- Fuel and fuel-element testing
- Structural materials, including Generation IV and life-time extension
- CNCF technologies, including minor actinide (MA) burning, multiple recycling, and radioactive waste (RAW) and spent nuclear fuel (SNF) handling
- Three loop channels with different coolants.

Construction of the facility began in 2015 and was 10% ahead of the original plans.

Energy–environment–economics

The Organisation for Economic Co-operation and Development (OECD) had set a decarbonisation target of 50 gCO_2 per kWh, which is to be achieved through an increased share of low-carbon sources, as well as drastically reduced levels of fossil fuels, working together in harmony to secure a reliable, affordable and clean future energy supply 24 hours a day. This will require large increases of all low-carbon energy sources, of which nuclear is an important part.

Many large cities have too few sun days to rely on solar energy and therefore need a combination of green energy sources. In this regard, highly concentrated sources of energy are important; among the green sources of energy, only nuclear and hydropower are sufficiently highly concentrated sources of energy, and only nuclear does not rely on natural processes such as river flow, wind or sun.

Society was moving in two opposite directions. On the one hand, countries need new energy sources thus increasing the curve of carbon-fuel usage; on the other hand, the usage of these fuels has to be minimised due to environmental pollution and the imperative for decarbonisation and reduction of greenhouse gas emissions.

The RAS is involved in the ROSATOM strategy, which focuses simultaneously on addressing issues related to energy, the environment and economics.

Nuclear energy now provides about 10% of the world's electricity from about 440 power reactors. Nuclear is the world's second-largest source of low-carbon power (29% of the total in 2018). Nuclear energy thus accounts for almost one-third of current worldwide energy production, and it needs to be understood that if nuclear energy were to be minimised, the emission of greenhouse gases would increase. In Russia, 16% of total energy production is currently from nuclear and it is planned to increase this to 25% by 2030.

Over 50 countries utilise nuclear energy in about 220 research reactors. In addition to research, these reactors are used for the production of medical and industrial isotopes, as well as for training. About 50 more reactors are under construction, equivalent to approximately 15% of existing capacity.

The first commercial nuclear power stations started operation in the 1950s. In the Eurasian continent, there was a relatively small nuclear power plant at Obninsk near Moscow, where the technologies that were originally developed for atomic weapon production were also used for the peaceful production of nuclear energy. The Obninsk Nuclear Power Plant operated for 48 years without any accidents. The plant is now a museum recording the history of the Soviet nuclear project and nuclear power plants.

The economy is also an important consideration. According to the International Energy Agency (IEA) *World Energy Outlook 2018*, the cost of electricity in China from onshore wind, solar photovoltaics and offshore wind is respectively 16%, 50% and 140% higher than that from nuclear. According to the OECD Nuclear Energy Agency, "a mix relying primarily on nuclear is the most cost-effective option to achieve the decarbonisation target of 50 gCO_2 per kWh."

In terms of the raw material base, uranium accounts for approximately 5% of the net cost of nuclear power generation (with the capital expenditure costs of nuclear power being extremely high), compared with 75% for fossil fuels, leading to more volatile markets for fossil fuels.

A significant comparison is that the average dose rates for the population living near coal power plants is at least 40% higher than for the population living near a nuclear power plant in regular non-accidental operation. The reason for this dosimetry is that when coal is burned, particulates emitted from coal-burning power plants typically contain very small amounts of uranium (<10 ppm).

The problems associated with nuclear generation include:

- **Social (public acceptance)**: social reactor safety issues, safety of spent nuclear fuel and radioactive management
- **Nuclear security and non-proliferation**
- **Scientific and technological issues**: including infrastructure for waste management and spent nuclear fuel
- **Options for geological disposal**: These include closed (reprocessing) and opened (once through) nuclear fuel complex

Science can address environmental and economic problems, but increasing the time period for the safe storage of nuclear spent fuel will have huge benefits for the economy and future generations.

The nuclear fuel cycle in Russia already re-uses uranium and plutonium. There is research into new chemistry to be incorporated in the cycle. The new strategy in Rusia is based on the combination of thermal neutron reactors with cheap energy generation and fast neutron reactors for recycling of fissile materials and burning up long-lived radionuclides from wastes.

The following conclusions can be reached:

- Megascience facilities lead to research breakthroughs in various critical fields (environment, new materials, pharmaceuticals and others).
- International collaboration in critical research areas is crucial.

- Nuclear energy is the best (or even the only) option for reaching the decarbonisation target of 50 gCO_2 per kWh.
- Nuclear waste is the major challenge in the development of safe and reliable nuclear energy.

Science had to be accompanied by education. Examples of productive collaboration with BRICS countries include the Shenzhen MSU-BIT University (SMBU), a joint university that has been successfully launched in Shenzhen between Lomonosov Moscow State University and the Beijing Institute of Technology. SMBU has the following faculties:

- Faculty of Philology
- Faculty of Mathematics and Cybernetics
- Faculty of Physics and Mathematics
- Faculty of Economics
- Faculty of Materials Sciences
- Faculty of Chemistry
- Faculty of Biology
- Faculty of Management
- Faculty of Arts
- Eurasia Research Centre
- Chinese Language Centre
- Faculty of Engineering

Leading education programmes from the two institutions are presented in Russian, English and Chinese. The teaching staff are from MSU and leading Chinese universities. Studying Chinese languages has become very popular for Russian students, although such knowledge is not required for admission.

Bachelor degree programmes are offered with two diplomas, either from MSU (Russia) or the Shenzhen MSU-BIT University (SMBU). Scholarship programmes are available covering up to 100% of the tuition fee. The magnificent campus is one of the most beautiful in China. Prof Kalmykov represents SMBU as a member of council.

2024 would be the 190th anniversary of the birth of Dmitri Mendeleev, the founder of the periodic table, and the 300th anniversary of the Russian Academy of Sciences. The Mendeleev Congress on General and Applied Chemistry was planned, bringing together approximately 3000 chemists. After the plenary sessions, the congress would be split into separate symposia. Prof Kalmykov was the convenor for the BRICS Symposium on Nuclear Chemistry, and encouraged the BRICS Academies to spread awareness of the event among researchers and scientists in their countries.

Discussion

Prof Burton thanked Prof Kalmykov for his wide-ranging presentation.

In response to a question from Dr Wright, Prof Kalmykov explained that the average dosage rate, and air pollution in general, of populations who live within a 10 km radius of a coal-fired power plant for ten years is 40% higher than for those living near a nuclear power plant.

In response to a question from Prof Mande on the opportunities for BRICS researchers to access the facilities of the RAS, Prof Kalmykov replied that the synchrotron would be open for foreign scientists to apply to visit to analyse their samples. There would also be onsite facilities for sample preparation, and separate facilities for radioactive materials and for biohazardous materials.

Prof Mehra thanked Prof Kalmykov for the presentation and especially for emphasising the safety aspects of nuclear power. He noted that COP28 was talking of alternative energy sources, including solar and oceans, but there are inequities in infrastructure between countries. Prof Kalmykov replied that the infrastructure is the starting point in dealing with nuclear waste management. ROSATOM's contracts with other countries include not only the nuclear reactor, but also the associated infrastructure. ROSATOM produces the fuel for the nuclear power plants, and then takes and reprocesses the fuel and sends it back to the country for geological disposal. ROSATOM is also responsible for the teaching and education of those who operate the nuclear power plant and all the related infrastructure.

Indian National Science Academy

One Earth, One Family, One Future: global polycrises and the need for interdisciplinary policy solutions (Prof Narinder K Mehra, Vice-President: International Affairs, INSA)

The theme for the 2023 G20 Summit, held in New Delhi in September 2023, was 'One Earth, one family, one future'.

Humanity's main challenges for the next 50 years are: clean energy, water, food and nutrition security, climate and environment, poverty alleviation, science in conflict zones, holistic health, education for all, population and global data sharing.

The dictionary definition of a 'polycrisis' is "A global polycrisis occurs when crises in multiple global systems become causally entangled in ways that significantly degrade humanity's prospects. These interacting crises produce harms greater than the sum of those harms the crises would produce in isolation."

This global polycrisis storm could be summarised under the main themes as follows:

Environmental:

- Climate-related risks
- Water pollution
- Toxification of all life
- Future pandemics and how to control them
- Climate change impact on human health
- Ozone depletion
- Anti-microbial resistance

Financial and Economic:

- Geoeconomic confrontation
- Supply chain disruption
- Inequality built into the global system
- Unsustainable economic growth
- Inequality built into the global system
- Externalising environmental and social costs

Social:

- Poverty
- Erosion of social cohesion
- Dysfunctional geopolitics

- Fertility decline
- War and nuclear threats
- Social injustice
- Child marriage (UNICEF)

Technological

- Uncontrolled technologies: artificial intelligence (AI), biotechnology, nanotechnology and robotics
- Displacement of people by robots
- Cyber threats
- Big data threats to democracy, privacy and human rights
- Modification of the human germline
- Electromagnetic frequency (EMF) pollution

The World Economic Forum (2023) had identified the global risks landscape as shown in Figure 1, illustrating the nature of the present polycrisis.

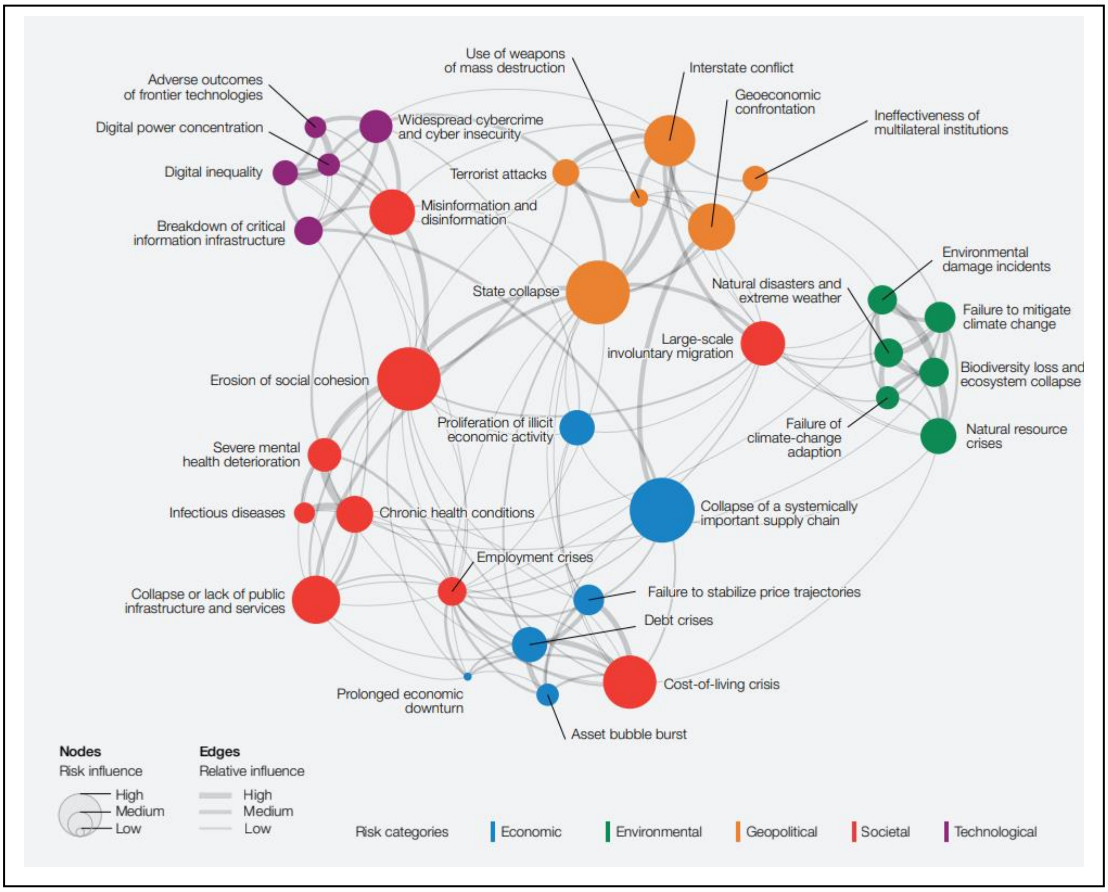

Figure 1: Global risks landscape

The challenges of navigating the polycrisis landscape include:

- **Socioeconomic impact of pandemics:** An example is the COVID-19 pandemic which had widespread global socioeconomic repercussions, disrupting lives, livelihoods, and the overall well-being of communities worldwide.

- **Global economic strain**: The global economy is under stress, with challenges that are contributing to weaker growth prospects.
- **Widening disparities**: There has been an alarming rise in poverty and inequality, which poses a significant threat to social cohesion and progress.
- **Food and energy security**: Increasingly, nations are facing severe food and energy insecurities, which threaten to reverse decades of development gains.
- **Inflation and debt**: High inflation rates and debt distress are putting additional pressures on already-strained economies, particularly in developing nations.
- **Climate change**: The escalating climate crisis continues to pose existential threats to ecosystems, economies and communities.

The alarming consequences of navigating the polycrisis landscape include:

- **Sustainable Development Goals (SDG) financing gap**: The financing needs for achieving the SDGs have dramatically increased, with an additional burden due to the COVID-19 pandemic.
- **Debt challenges in developing countries**: A significant number of developing countries are facing high levels of indebtedness, which limits their ability to respond to the polycrisis.
- **Official development assistance (ODA) trends**: Despite a slight increase in ODA, there is concern that it is not effectively reaching the most vulnerable populations. There is a notable downward trend in ODA for sexual and reproductive health and rights, which is crucial for social development.

In its 2023 *Global Outlook*, UNICEF considered the prospects for children in the polycrisis:

- While the harms caused by the COVID pandemic continued to be counted, reforms of health architecture and medical breakthroughs offered new hope for children.
- Efforts to tame inflation would have unintended negative effects on child poverty and well-being, requiring policy measures that protect investments for vulnerable families and children.
- Multiple factors would contribute to continued food and nutrition insecurity, with increasing calls for greater climate adaptation and food systems reform to prevent food poverty in children.
- The worsening energy crisis might cause immediate harm to children, but the focus on energy sustainability provided hope for a greener future.
- Unmet needs and underinvestment in children warranted reforms of financial flows to developing countries, while renewed attention on climate, finance and debt relief held promise.

At the core of the polycrisis are the human beings. In Prof Mehra's view, the major challenges facing human beings would be related to health (particularly antimicrobial resistance [AMR] and zoonotic spillovers) and climate. Human health is determined by the interaction of the environment with the genome, epigenome and microbiome, all of which shape the transcriptomic, proteomic and metabolomic landscape of cells and tissues.

Human health is determined by the composite environment, including soil health, plant health, animal and human health (including nutrition and immunity), and these are all influenced by the wider environment where climate change, air quality, water quality and pervasive microbes play a role.

To address these challenges, the Food and Agriculture Organization of the United Nations (FAO), United Nations Environment Programme (UNEP), World Health Organization (WHO) and World Organisation for Animal Health (WOAH) have formed the Quadripartite Alliance for One Health. At a meeting in Rome in March 2022, they adopted the *One Health Joint Plan of Action (2022–2026): Working together for the health of humans, animals, plants and the environment*. The report promotes the concept of One Health for the prevention of zoonotic spillovers that pose the danger of advancing from local outbreaks to global pandemics. The alliance will involve commitment to ecological sustainability, linked microbial surveillance across wildlife, veterinary populations and human habitat, and speedy knowledge-sharing of emerging infections at the global level. The capacity for genomic surveillance must be enhanced in all countries; this became especially clear during the COVID-19 pandemic when it was felt that each country should increase its capacity for genomic surveillance. The One Health framework needs to be developed to address issues related to the sustainability of the shared planet.

The immediate concerns are:

- Rapid spread of AMR germs across communities
- Increase in vector-borne diseases due to warmer temperatures (2023 has been declared the warmest year for 100 years).
- Threat to food supplies, livelihoods and economies from diseases in food animals
- Growing global concern about air pollution and environmental contaminants.

The concept of One Health promotes a sustainable and healthy future through the 4Cs: collaboration, communication, coordination and capacity building. The One Health Joint Plan of Action outlines the commitment of the four organisations to collectively advocate and support the implementation of One Health.

The Joint Plan of Action is built around six interdependent action tracks that collectively contribute to achieving sustainable health and food systems, reduced global health threats and improved ecosystem management:

- Action track 1: Enhancing One Health capacities to strengthen health systems
- Action track 2: Reducing the risks from emerging and re-emerging zoonotic epidemics and pandemics
- Action track 3: Controlling and eliminating endemic zoonotic, neglected tropical and vector-borne diseases
- Action track 4: Strengthening the assessment, management and communication of food safety risks
- Action track 5: Curbing the silent pandemic of AMR
- Action track 6: Integrating the environment into One Health

Human, animal and environmental health are interconnected and must be addressed together to achieve 'universal holistic health'. One Health and Planetary Health encourage inclusivity and holism for sustainability.

There is a rising threat of diet-related non-communicable diseases, the four main ones being cardiovascular diseases, cancer, chronic respiratory diseases and diabetes. Others include hypertension, dyslipidaemia, obesity, metabolic syndrome, rheumatoid arthritis, cerebrovascular disease, osteopenia, osteoporosis, degenerative skin disease, sarcopenia and frailty, depression, cognitive impairment and neurodegenerative disease.

Factors include unhealthy diet, physical inactivity, tobacco use, consumption of alcohol, and pollution. Prevention and control require healthy lifestyles. According to the WHO, a healthy lifestyle requires regular physical activities, avoiding smoking, limited alcohol consumption, and a healthy diet to prevent overweight and obesity. These habits will lead to better physical health and foster mental wellbeing. The role of traditional diets versus modern diets that are heavily loaded with ultra-processed foods should also be evaluated. It is hypothesised that inflammation from fine particles in air pollution increases the risk of type 2 diabetes.

Artificial intelligence has the potential to transform the health sector through the interpretation of images (e.g. X-ray, CT scan, MRI); detecting pre-cancer growth during scanning; predicting possible outcomes from diseases; detecting life-threatening conditions; and precision medicine. The advantages of using AI in the health sector include:

- Catching what doctors can miss
- Quicker and more consistent
- Boost for remote areas
- Analyses trends while reading scans
- Prioritisation of critical scans
- Identification of the efficacy of drugs for individual patients.
- Google had worked with a large team of ophthalmologists to develop an AI scan to detect diabetic retinopathy.

Prof Mehra proposed the need to develop a BRICS exhortation for 'AI for holistic human health'.

Anti-microbial resistance (AMR) is a significant and growing threat to human health. AMR refers to microorganisms such as bacteria, fungi, viruses and parasites being able to resist the effects of antimicrobial drugs that were earlier effective in treating infections. Due to this, the treatment and management of even common infections like pneumonia has become challenging. This must be curbed by preventing misuse of anti-microbial drugs in both human and veterinary populations as well as in agriculture, especially fish farming. Knowledge of emerging drug resistance, in any microbial species, must be speedily communicated to the international scientific community.

Climate degradation must be prevented through science-based approaches to develop strategies for adaptation to global warming, so that adverse effects on human, animal and plant health can be minimised. Inclusive scientific collaboration must be supported by mobilisation and sharing of resources, and BRICS is an important forum in this regard.

In 2019, AMR was associated with over 5 million fatalities, 1.3 million of which were directly due to bacterial AMR. Excessive and incomplete use of antibiotics by humans and for animals has led to AMR, with 30% attributable to overuse by humans and 70% for animals. Industrial effluents containing pharmaceuticals have also contributed.

The Indian Council of Medical Research conducted a study of AMR in 21 tertiary care hospitals across India for the period January–December 2022, in which 100 000 culture isolates were analysed for hospital-acquired infections, and 1 747 pathogens were found. *Escherichia coli* was the most common, followed by *Klebsiella pneumoniae*.

The study revealed that eight out of ten patients with drug-resistant *E. coli* infection responded to Carbapenem (a drug that effectively treats pneumonia and septicaemia) in 2017, but the figure dropped to six out of ten by 2022. The situation was worse with the drug-resistant *K. pneumoniae*, in which only four out of ten patients now benefit from the drug.

Globally, the resistance levels of between 10% and 20% are considered to be alarming; nevertheless, in some countries including India there is widespread and uncontrolled use of antibiotics, such that even patients with over 60% resistance levels are being prescribed antibiotics. A strong policy must be in place to curb this. The BRICS Academies would be an important forum to devise such a policy.

A recent article published in *The Lancet Planetary Health Journal* found that the increasing incidence of antibiotic resistance may be linked to rising air pollution, and attributed 480 000 premature deaths in 2018 to AMR, incurring additional economic costs of $ 395 billion. It is predicted that by 2050, 840 000 deaths annually are likely to be due to antibiotic resistance.

A study by the European Environment Agency in 2021 found harm to human health from air pollution in Europe and mortality due to exposure to fine particulate matter ($PM_{2.5}$) and nitrogen dioxide (NO_2). The greatest harm to human health (burden of disease) is from ischemic heart disease for $PM_{2.5}$ and diabetes mellitus for NO_2. Between 2005 and 2021, the number of deaths in the European Union attributable to air pollution fell by 41%, but air pollutant concentrations in 2021 remained well above the levels recommended by the WHO in its air quality guidelines.

A recent study by the Energy Policy Institute at the University of Chicago estimated reduced life span of nearly 12 years due to air pollution for residents of Delhi. The impact of $PM_{2.5}$ on global life expectancy is comparable to that of smoking, and more than three times that of alcohol use. In India, air pollution reduces average life expectancy by 5.3 years, and by 11.9 years for residents of Delhi.

China's air pollution has declined by 42.3% since 2013, the year before the country began a 'War against pollution'. Due to this, an average Chinese can expect to live 2.2 years longer. The Air Quality Life Index (AQLI) shows that reducing global pollution to meet the WHO standards ($PM_{2.5}<5\ \mu g/m^3$) will add 2.3 years in average life expectancy globally. Since the USA passed the Clean Air Act, pollution has decreased by 64.9%, extending the average American lifespan by at least 1.4 years. Delhi is the most polluted megacity in the world with annual average particulate pollution of 126.5 $\mu g/m^3$. This is more than 25 times the WHO guidelines.

Industrialisation, economic development and population growth have all led to skyrocketing energy demands and fossil fuel use across the region. In India, the number of vehicles on the road has increased about four-fold since the early 2000s. India has revamped its National Clean Air Programme (NCAP) goal, aiming to achieve 40% reduction in particulate pollution levels by 2026.

The InterAcademy Partnership (IAP) published its report entitled *Health in the climate emergency: A global perspective* in May 2022, pointing out that climate change is having a range of impacts on health today that will become more severe unless urgent action is taken. Climate change dramatically threatens human health, putting billions of people at risk through heat-related mortality and morbidity; extreme events such as floods and droughts; decreases in crop yield in some regions; changes in the distribution of vector-borne diseases; and wildfires causing widespread exposure to air pollution.

The effects of climate change on health are most severe for those in low socio-economic conditions and marginalised groups, influenced by factors such as health status; social, economic and environmental conditions; and governance structures. In this regard, the next priorities include:

- Building a regional network of climate and health collaborators and stakeholders
- Identifying local and regional climate-sensitive infectious disease risks, with the aim of designing and testing of interventions
- Developing innovative solutions to climate-driven health challenges, through integration of novel digital technologies, remote patient monitors, mHealth initiatives (applications that use a smartphone's inbuilt tools to automatically detect and measure health-related behaviours) and AI methodologies
- Developing engagement activities with vulnerable communities to understand their priorities and the potential impact of climate change on mental health

- Expanding communication and engagement with government and NGOs, community-based organisations and others to develop action to be taken in local and national policy-making spheres.

Ahead of the G7 Summit, science academies have published statements on the urgent need for climate protection, energy transition and pandemic preparedness. The science academies of the G7 States have called for urgent international action to protect the ocean and polar regions; accelerating climate neutrality by 2050; ensuring the global protection of marine ecosystems; and reducing greenhouse gas emissions. In the healthcare sector, scientists demand increased global pandemic preparedness including new antiviral drugs, the establishment of an international coordination body for clinical studies, and the implementation of a One Health approach that considers the health of humans, animals, plants and the wider environment as closely linked and interdependent. Recommendations were submitted to the German Federal government during the G-Sciences Forum in Berlin in June 2022.

Zoonotic spillover has emerged as a poignant example of profound interconnections between environmental degradation and public health crises. The relentless encroachment of human activities into natural habitats has disrupted delicate ecosystems and set the stage for the emergence and transmission of zoonotic diseases. This alarming trend underscores the urgent need for policies that harmonise environmental stewardship with public health objectives. A comprehensive approach, integrating robust wildlife management, sustainable land use, and proactive disease surveillance, is imperative to mitigate the risks of future pandemics. This calls for an unprecedented level of interdisciplinary collaboration and commitment with delicate balance between human activity and the natural world, ensuring a sustainable future for both.

The Future Earth *Risks Perceptions Report 2020* draws insights from more than 200 global change scientists across 52 countries and highlights the tightly woven fabric of environmental and societal risks that are rapidly turning into a global systemic crises. There is a need for a paradigm shift in policy making, using a multidimensional approach with emphasis on integrating environmental and societal risks rather than addressing them in isolation.

The COVID-19 pandemic revealed 'global inequities' in healthcare infrastructure and coverage. According to the Centre for Disease Control and Prevention, "equity in healthcare is achieved when every person has the opportunity to 'attain his or her full health potential' and no one is 'disadvantaged' because of social position and/or other socially determined circumstances". Frontier and Transformative technologies such as AI, internet of things (IoT), blockchain, robotics, 3D printing, gene editing, virtual reality (VR) and digital health tools are revolutionising the healthcare industry globally, due to their potential for improved accuracy of diagnosis as well as better quality of life. The moot issue is the question of equitable access to all.

Interdisciplinary policy solutions are proposed. Recognising the interdependent nature of global polycrises (ranging from pandemics to climate change, economic disparities and technological disruptions) the BRICS Academies Forum can call for a paradigm shift in international policy-making. Embracing the ethos of 'One Earth, one family, one future', this forum can propose a collective march towards resilience and sustainability through interdisciplinary approaches:

1. **Sustainable development integration**: Developing policies that integrate economic, environmental and social goals, ensuring that actions in one area do not compromise another, underpinned by the Sustainable Development Goals as a guiding framework.
2. **Public health and environmental stewardship**: Investing in public health systems that recognise the intrinsic link between human health and the environment, promoting policies

that are preventative rather than reactive, and that leverage the expertise from environmental scientists, urban planners and public health officials.

3. **Innovative economic models**: Encourage the adoption of circular economy models and sustainable finance, driving innovation and efficiency while reducing environmental impact. This requires collaboration between economists, ecologists and business experts.
4. **Technological equity and access**: Ensure equitable access to technology and data, fostering an environment where technological advances are shared and contribute to the collective well-being, demanding a partnership between technologists, policymakers and ethicists.
5. **Education and multidisciplinary research**: Reform education systems to promote interdisciplinary learning and research, equipping future generations with the skills to address complex global challenges through cooperation across scientific disciplines.
6. **Climate action and energy transition**: Fast-track policies for a global energy transition to renewable sources, integrating insights from climate science, engineering and economics to create a roadmap for a carbon-neutral future.
7. **Cultural and societal inclusivity**: Forge policies that embrace cultural diversity and societal inclusivity, recognising the importance of indigenous knowledge and local expertise in crafting global solutions, necessitating the involvement of social scientists, anthropologists and community leaders.

Discussion

Prof Burton thanked Prof Mehra for the very comprehensive presentation, which had raised many issues that the forum could debate. She thanked both the speakers for their deep and comprehensive reviews of their perceptions of the polycrisis.

Chinese Academy of Sciences (CAS)

The presentation by the Chinese Academy of Sciences was jointly presented by Prof Gensuo Jia who presented on the problems related to the polycrisis, and Prof Chunliang Fan who presented on the solutions.

Coupled changes of climate and ecosystems: from crisis to nature-based solutions (Prof Gensuo Jia, Institute of Atmospheric Physics, CAS)

The hybrid BRICS Forum on Big Data in support of the Sustainable Development Goals (SDGs) was hosted in Beijing in April 2022. One of the five themes of the forum was 'Climate actions and disaster reduction'. Scientists from all five BRICS countries participated in the event, including two from South Africa (one from the University of Cape Town and the other from the Kruger National Park).

With respect to the land–atmosphere interface, the stance of the Fifth Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC AR5) is that the biophysical impacts of land use change on climate are considered to be locally significant only; however, increasing evidence suggests that these impacts may go well beyond local level.

The United Nations Environment Programme (UNEP) identified the triple planetary crisis (land degradation, climate change and biodiversity loss) and recently added a fourth crisis, namely reduced human wellbeing. The three elements of the triple planetary crisis need to be addressed together in order to sustain human wellbeing.

In 2019, the IPCC published the Special Report on Climate Change and Land and a summary for policymakers1. In this special report, the IPCC dealt with the linkages between terrestrial ecosystems and climate change. Chapter 2 of the report deals with land–climate interaction. The report highlighted that climate change and variability lead to desertification and land degradation and affect food security. The report discussed terrestrial greenhouse gas (GHG) and non-GHG fluxes and stocks; the impact of land feedback and forcing on climate via multiple pathways; land-based adaptation and mitigation options leading to climate forcing; couplings between changes in the climate system and biogeochemistry; and global hydro climatological teleconnections resulting from tropical deforestation.

The IAP (of which the BRICS Academies are members) published the *Statement on Climate Change and Biodiversity: Interlinkages and policy options* in 2021. The report had 16 authors and has been endorsed by 82 academies. The report highlighted the dual challenges of interlinked climate change and biodiversity; the role of ecosystem services in supporting climate action; going beyond land use to consider sustainable land management; and using nature-based solutions to address biodiversity loss and climate change. The report called for cooperation and coordinated action by the two conventions, namely the UNFCCC and the Convention on Biological Diversity (CBD).

The UNFCCC COP26 in 2021 paid major attention to nature–climate solutions and passed resolutions to stop deforestation (over 120 nations promised to do so), enhance nature conservation, move towards sustainable land management and cut CH_4 (methane) emissions from ecosystems and agriculture. This was an important milestone for the UNFCCC in going beyond greenhouse gas emission control and talking about how to fund ecosystem solutions.

COP27 in 2022 further focused on how the ecosystem and society respond to the climate damage. The keywords of the conference were loss and damage (including how to identify climate loss and damage from climate change, attributing the sources, and making funding available to address these); while COP28 in 2023 addressed monitoring climate change effects, funding and early warning.

The Big Earth Data Science Engineering Program (CASEarth) was launched by CAS in 2018 with the aim of developing a digital Earth platform to host big data and cloud services and to cater to modern data-intensive scientific applications for a wide variety of fields including resource management, environmental sciences, biology, ecology and many others. The platform allows technological innovations in the field of Earth-related big data, supports major breakthroughs and scientific discoveries in Earth system science, enables comprehensive macro-level decision-making support and public knowledge dissemination services, and also functions as a science-based decision support system for developing major domestic and foreign strategies. The system also provides support to the Sustainable Development Goals (SDGs).

The report on *Big Earth Data in Support of the Sustainable Development Goals* was released in September 2020 by the Chinese government. The report, drafted by CAS, showcases China's efforts of using innovation-driven technologies to implement the 2030 Agenda, and in particular, the prospect of utilising big Earth data for monitoring and evaluating the implementation of the SDGs. The report focuses on six SDGs including Zero Hunger (SDG 2), Clean Water and Sanitation (SDG 6), Sustainable Cities and Communities (SDG 11), Climate Action (SDG 13), Life below Water (SDG 14), and Life on Land (SDG 15). The case studies present the use of big Earth data for developing data products, new evaluation methodologies and models to monitor progress and inform policy-making at local, national, regional and global scales.

The big Earth data module on climate change demonstrates that loss and damage takes place through both slow and fast processes:

- **Slow processes**, for which drought, ecosystem degradation and restoration are monitored. The monitoring of meteorological drought is critically important for tropical and subtropical water-limited ecosystems, which play key roles in the global carbon cycle and ecosystem services. The Microwave Integrated Drought Index (MIDI), a multi-sensor microwave remote sensing drought index integrating state-of-the-art multiple satellite microwave-derived precipitation, soil moisture and land surface temperature information, has been developed to improve the meteorological drought monitoring capability of satellite remote sensing. MIDI contributes to climate extreme prediction and risk assessment over Africa and Asia. MIDI data are now being released monthly.
- **Fast processes**, for which fire, flood, hurricane and heatwave are monitored. The factors involved in the fast processes include heatwave hotspots and impacts in Africa, with nighttime heatwaves linked to urban clusters[1]; and the urban population, water and energy footprint.

Prof Jia referred to several studies on climate change effects in which he had been one of the principal investigators:

- A 2022 study[2] warned how deforestation triggers irreversible transition in the Amazon hydrological cycle. Deforestation enhances the fire risk through moisture decoupling over the canopy gap, with water cycle effects.
- A 2020 study[3] drew attention to the climate effects of earlier leaf-out in pan-Arctic. The study was a meta-analysis of spring onset through Earth system modelling, and found that the earlier leaf-out was caused by warming in high and mid latitudes.
- A 2022 study[4] found that global protected areas buffer warming and provide thermal refugia.
- A 2022 study[5] found that reforestation enhanced landscape connectivity and climate buffering in China, with reduced fragmentation and edge effects. The core forest creates a cooler habitat, with reduced diurnal and seasonal temperature range.

The presentation reached the following conclusions:

- Humanity is facing the coupled crisis of climate change and ecosystem degradation.
- Climate change and extremes increasingly threaten the viability and resilience of natural ecosystems.
- Ecosystems play an active role in regulating climate system via carbon flux and biophysical feedback.
- Climate change and ecosystem degradation will not be successfully resolved unless both are tackled together
- Joint scientific research is proposed on climate–ecosystem–land use interactions among BRICS Academies, using in situ, satellite and modelling networks, in order to fill knowledge gaps towards nature-based solutions.

---

[1] Igun, E., X. Xu, Z. Shi, G. Jia*, 2023: Enhanced nighttime heatwaves over African urban clusters, Environmental Research Letters, 18, 014001, doi: 10.1088/1748-9326/aca920

[2] Xu, X., X. Zhang, W.J. Riley, Y. Xue, C.A. Nobre, T.E. Lovejoy, G. Jia*, 2022: Deforestation triggering irreversible transition in Amazon hydrological cycle, Environmental Research Letters

[3] Xu, X., W.J. Riley, C.D. Koven, G. Jia*, X. Zhang, 2020: Earlier leaf-out warms air in the north, Nature Climate Change

[4] Xu*, X., A. Huang, E. Belle, P. De Frenne, G. Jia*, 2022: Protected areas provide thermal buffer against climate change, Science Advances, 8, eabo0119

[5] Huang, A., R. Shen, G. Jia, X. Xu, 2022: Reforestation enhanced landscape connectivity for climate buffering in China, Environmental Research Letters, 17(1): 014056

Energy development pathways and policies under peak carbon, carbon neutral targets (Prof Chunliang Fan, Institutes of Science and Development, CAS)

Climate change is a common global challenge. Addressing climate change has a bearing on the future of humankind and on the sustainable development of the Chinese nation. China has always attached great importance to combating climate change, and has firmly pursued a high-quality development path that gives priority to ecology and is green and low-carbon based. China is committed to promoting harmonious coexistence between human beings and nature, and promoting the building of a global community of life.

Against this background, the Ministry of Ecology and Environment of the People's Republic of China released the *Annual Report on China's Policies and Actions to Address Climate Change 2023* on 27 October 2023, which clarifies that China's main tasks in addressing climate change are:

- Accelerating the green and low-carbon transformation of the development mode
- Actively and steadily pushing forward carbon peaking and carbon neutrality
- Actively participating in global governance to address climate change.

Energy development occupies a very important position in the framework of China's goal of achieving peak carbon and carbon neutrality (dual-carbon), and the purpose of the report is to explore the pathways and policies for China's energy development in the context of the dual-carbon goal.

The content of the report addressed:

- Lessons from the major countries' dual-carbon targets
- Challenges to achieving carbon neutrality in China
- Achievements and problems in China's energy development under the dual-carbon target
- Major policy recommendations for China's future energy development under the dual-carbon target

Lessons from the major countries' dual-carbon targets

International experience shows that in order to achieve the goals of carbon peaking and carbon neutrality, it is necessary to do overall planning, focus on key industries and steadily push forward the work of emission reduction, so as to achieve a coordinated and parallel relationship between the response to climate change, and economic and social development:

- In the energy production industry, accelerating the construction of a clean and low-carbon energy system, promoting the combination of renewable-energy power generation and energy-storage technologies, and realising the deep decarbonisation of the power system
- In the transport sector, improving transport infrastructure facilities and promoting the digitalisation of the transport system; achieving the replacement of fuel vehicles by electric and hydrogen-fuelled vehicles
- In the area of construction, energy-saving renovation of old buildings and the creation of carbon-neutral buildings in accordance with green building standards
- In the industrial sector, improving energy efficiency and controlling coal consumption
- In agriculture, planting trees and supporting the development of carbon capture technologies to offset unavoidable carbon emissions and achieve net-zero carbon emissions.

Challenges to achieving carbon neutrality in China

Firstly, the time from peak carbon to carbon neutrality in China is much shorter than that in developed countries. The time from peak carbon to carbon neutrality in China is 13 years less than that of the USA, 30 years less than that of the European Union and 13 years less than that of Canada. The difficulty of achieving carbon neutrality is much higher than that of any developed country.

Secondly, the high carbon lock-in effect caused by the coal-based energy structure is a major obstacle to China's goal of achieving carbon peaks.

Thirdly, China is in the middle to late stages of industrialisation and urbanisation, and economic growth is still dependent on the growth of energy consumption.

Fourthly, the lack of core technology is also an important challenge that China must face.

Achievements and problems in China's energy development under the dual-carbon target

China has taken a number of approaches to achieving its dual-carbon goals:

- Promoting technological advances in energy efficiency to achieve a reduction in carbon emissions
- Reducing carbon emissions by adjusting the industrial structure
- Developing renewable energy power generation and adjusting the energy structure to drive down carbon emissions
- Guiding the transformation of the energy consumption structure towards electrification, cleanliness, low carbonisation and high efficiency
- Planting trees and increasing green areas.

China has made great progress towards achieving its dual-carbon goals, but there are also many problems.

Policy recommendations

The following major policy recommendations are proposed for China's future energy development under the dual-carbon target:

For energy-consuming industries:
- On the energy supply side, making a scientific layout and connection for the renewable energy power-generation network to promote energy cleanliness
- On the energy consumption side, fully implementing the terminal energy and electric energy replacement project
- Promoting a number of major green and low-carbon technologies.

For the technological system for new energy development:
- In the technical system of new energy development, firstly, strengthening the top-level design of new energy technology to guide research and development and innovation, and strengthening the scientific research of key core technologies.
- Building an innovation network through the innovation value chain to improve the efficiency of research and production transformation
- Establishing a supporting security system for the development of large-scale energy storage technology, hydrogen energy, solar fuel/chemical technology and energy Internet.

For the financial guarantee to achieve the dual-carbon goal:

- Improving the carbon trading mechanism and optimising the carbon market environment
- Dual-carbon planning with Chinese characteristics should consider the regional dimension as the main framework and the industry dimension as the main content basis, to form a 'region–urban cluster city–industry–enterprise' decomposable vertical management system of path planning.

Discussion

Prof Burton thanked the speakers for their very different viewpoints.

Academy of Science of South Africa (ASSAf)

South Africa in polycrises and developmental challenges (Profr Pat Naidoo, Visiting Scholar, University of Johannesburg; Prof Caradee Wright, Chief Specialist Scientist, South African Medical Research Council; Prof Himla Soodyall, Executive Officer, ASSAf)

ASSAf had started by trying to understand what is meant by 'polycrisis' and concluded that polycrisis is a series of crises occurring at the same time. The risks interconnect and combine to create an outcome that is worse than the sum of its parts. The World Economic Forum, at a meeting in Davos, Switzerland in January 2023, defined 2023 as the Year of Polycrisis, describing the present as "a time of great disagreement, confusion, and suffering".

The developing world had had its fair share of polycrisis over time, but the effects were now also being felt by advanced economies in the form of rising cost of living, increasing food and energy prices, rising inflation, accelerating migration, insatiable resource demands, increasing conflicts in complexity and duration, and stretched national assets.

South Africa is experiencing a complexity of problems and challenges. In a 2023 publication, the Institute of Risk Management of South Africa referred to South Africa as a "failed state and mafia state", citing social unrest, riots, poor service delivery, poverty, high unemployment, corruption, persistent inequality, no or slow economic growth or regression, failing public infrastructure, decarbonisation impact on the economy and technological disruptions."

Today's world is fragmented, facing extreme weather events. The most challenging present-day risk was the cost of living, and the biggest future existential threat was climate-related risks.

ASSAf considered the areas that the BRICS Academies Forum has the capacity to lead and identified the cost of living risk and the climate existential threat risk. The forum could address these through pooling of resources, research collaboration, and knowledge and praxis sharing.

Climate related risks: the existential threat

The Paris Agreement adopted by COP21 in December 2015 requires each party to prepare, communicate and maintain successive nationally determined contributions (NDCs) that it intends to achieve. Parties shall pursue domestic mitigation measures, with the aim of achieving the objectives of such contributions. The NDCs aim to reach global peaking of greenhouse gas (GHG) emissions as soon as possible so as to reach carbon neutrality. The intention is to undertake rapid, science-directed reductions thereafter to achieve a balance between anthropogenic emissions by sources and removals by sinks of GHGs in the second half of this century (2050 to 2100).

The BRICS countries had delivered the following commitments to COP28 with respect to reaching carbon neutrality: Brazil by 2050, Russia by 2050, India by 2070, China by 2060, and South Africa by 2050. The measures that would be required to meet these targets include the reduction of emission intensity of the gross domestic product (GDP); electric power from non-fossil resources; carbon sink from forests and trees; and adaptation starting with the most vulnerable. Developing economies, facing huge social challenges, will have to mobilise funding from industrialised economies.

South Africa and the cost-of-living crisis

South Africa is experiencing rising food prices, and the poor are struggling most. There is high unemployment, leaving the youth stranded. Although the graduate unemployment rate remains low in South Africa compared to those of other education levels, unemployment among the youth continues to be a burden irrespective of education level. The national crises are exacerbated by the unavailability of electricity, which is a national disaster. At the core of the challenges is the fact that there is no economic growth.

Polycrisis framework for South Africa

A polycrisis framework was proposed, comprising the identification and definition of the problem, potential solutions (which require capacity, resources and commitment), prioritisation and budgeting toa address the challenges, and monitoring and evaluation to assess the extent of progress towards the solutions, as well as learning tools to apply learned experience to future initiatives. Following this structure, a polycrisis framework was developed for two areas, namely society (related to inequalities and social distress) and governance related to international coordination.

Society: Inequalities and social distress	
Problem identification and definition	Inclusivity (gender, race and disability) Quality early childhood development Unemployment (economic growth May and skills mismatch) Public healthcare confidence Climate-resilient society and just energy security
Potential solutions	Improved educational development Sound social safety and security net Improve all basic services, i.e., water, sanitation, waste collection Improve public healthcare services and infrastructure Improve support for youths and people with disability programmes Improve digital connectivity Improve societal sense of belonging/dignity and spatial norms
Prioritisation and budgeting	Social compacts to reduce poverty and inequality in a meaningful way Create fluid service-delivery mechanisms
Monitoring, evaluation and learning tools	Statistics South Africa Quarterly Labour Force Reports Social Progress Index

Governance: International coordination	
Problem identification and definition	Regional migration Geo-politics Economic inequalities amongst countries International law and justice Regional politics Corruption
Potential solutions	Inclusive growth through policy actions Collective sustainability management Improve existential policy implementation Establish a competitive base of legislative and regulatory frameworks Improve regional cooperation Install governance and legitimacy of public systems
Prioritisation and budgeting	Implementation of international pacts on financing for development
Monitoring, evaluation and learning tools	National Development Plan The Presidency Strategic Plan 2020–2025

Polycrisis, BRICS and health issues

Health was shown as an example of the effects of the polyresins, since the multiple determinants of health are both social and economic. The polycrisis in health in the BRICS countries is exacerbated by economic challenges, social and health inequalities and the impact of the COVID-19 pandemic, as illustrated in Figure 2.

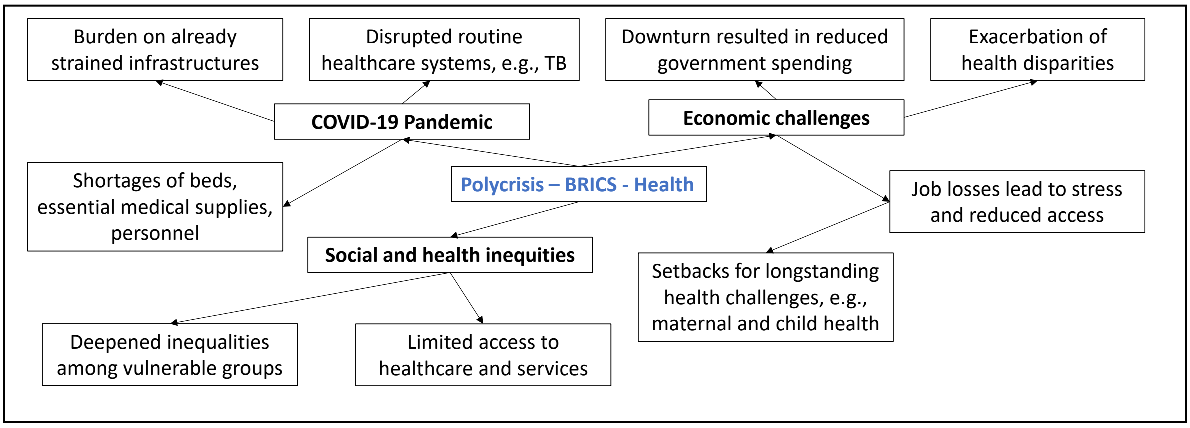

Figure 2: Polycrisis in health in BRICS countries

Addressing the health impacts of the polycrisis in BRICS countries requires not only immediate measures to strengthen the healthcare systems, but also a comprehensive approach that tackles underlying social and economic determinants of health.

As the BRICS nations navigate the polycrisis, addressing health challenges becomes paramount, requiring collaborative efforts and innovative solutions for a resilient future.

The national fiscus

Funds are required from the national fiscus to address the polycrisis. The issue then becomes what criteria inform the identification and prioritisation of various aspects of the polycrisis, and how public resources such as budgets are influenced by the polycrisis.

The impact on the national fiscus of present-day poor economic growth leads to lower levels of national tax collection. The problems are multifaceted. Increasing social security impacts on national debt, increased borrowings, higher interest payments and less capital for infrastructure development, with cumulative impacts on the failing public utility basic services of energy, water, sanitation, housing, etc.

With respect to monitoring and evaluation, the Institute of Risk Management of South Africa tracks both national risks and risk management strategies. The 9th edition of their *Annual Risk Report* reflects great inability to arrest the polycrisis.

Statistics South Africa is responsible for monitoring and reporting on progress towards meeting the targets of the SDGs.

Role of ASSAf with respect to the polycrisis

ASSAf can do much not only to profile the polycrisis but as a driving force to set initiatives in motion, including:

- **Engagement with stakeholders within the national system of innovation**: ASSAf has the capacity to bring together a range of stakeholders. ASSAf membership is currently 689 individuals across all disciplines of science, representing a significant resource that can be brought into the portals of discussion. ASSAf can draw on the expertise of the top academics in its membership as well as from among the South African Young Academy of Science (SAYAS) and other partners; however, academics, who account for the bulk of the membership, are very busy with their institutional responsibilities in relation to teaching, research and community engagement, and when ASSAf calls upon them, this represents an added layer of responsibility.
- **Standing committees**: ASSAf mobilises the capacity at its disposal to address societal challenges through its Standing Committees (Health; Science, Technology, Engineering, Mathematics and Innovation; Humanities; Biosafety and Biosecurity; Reduction of Poverty and Inequalities). ASSAf also has the standing Committee on Scholarly Publishing in South Africa, which among others considers the needs of open science and open data.
- **Just Transition Forum**: The forum was set up over the past two years and had developed a draft statement that would soon be finalised and issued with respect to the energy crisis in the country. In this regard, ASSAf would be working together with the Engineering Academy of South Africa (represented in the present forum by Prof Pat Naidoo).
- **Forum on Water and Sanitation**: During the Water Security Seminar convened by ASSAf in March 2023, ASSAf released the Water Security Statement. ASSAf would now explore how aspects of water and health intersect.
- **Forum on Integrated Climate Change Response**: The Standing Committee on Reduction of Poverty and Inequalities had also embraced issues related to climate change, but the ASSAf Council had requested that climate change be elevated as a priority. ASSAf would shortly be issuing a formal integrated climate change response. South Africa has many scientists and research groups working on climate change; for example, the School for Climate Studies at Stellenbosch University, the University of the Witwatersrand has a strong presence, and a number of South African scientists contribute to the international discussions and publications on climate change. The role of ASSAf is not to become

involved in the empirical research but to bring the conversations to the fore to explore an integrated approach, not only to climate change but to all the areas that ASSAf is addressing.
- **Science engagement and communication strategy** to build trust with the public on science, technology and innovation (STI) in advancing societal issues is an integral part of the scientific enterprise. Researchers need to be able to summarise what they do and why it is important in ways that the general public understand. During the COVID-19 pandemic, the Human Sciences Research Council was commissioned by the Department of Science and Innovation (DSI) to conduct a survey of public perceptions of science. Across the country, over 6000 people over the age of 16 participated in the survey. From the survey, data are available on what the general population understand about science, how they interpret science, and the medium by which they access science. The survey showed that television is the primary medium via which people access information on science, followed by radio, and less by social media. ASSAf had recently worked on a draft Strategic Plan for Science Engagement and Communication. The DSI would align its top-down strategy with ASSAf's bottom-up approach to develop a more sophisticated way of advancing science of relevance to society.

ASSAf reports to the DSI and during the meeting on 1 December 2023 with the programme at the DSI that oversees ASSAf, it was apparent that there would be a significant cut in the budget. South Africa's ratio on the proportion of GDP spent on research is far below the target, and there is a downward spiral in funding and the national performance in STI. Yet scientists are expected to do more with fewer resources. A national discussion is required on how to mitigate these challenges of the current environment.

The technical team who had been involved in drafting the paper presented to the BRICS Academies Forum comprised Dr Rasigan Maharajh, Prof Caradee Wright and Prof Pat Naidoo. Prof Soodyall also acknowledged the ASSAf Council members who had been involved: Prof Stephanie Burton (Acting President) and Prof Evance Kalula.

The members of the ASSAf secretariat who had been involved were Prof Himla Soodyall, Dr Melusi Thwala, Dr Tozama Qwebani, Mr Aluwani Elijah Ramulifho, Mr Ian Shendelana, Ms Marvin Mandiwana and Ms Henriette Wagner.

Mr Daan du Toit (Deputy Director-General: International Cooperation and Resources, DSI), was thanked for endorsing and supporting the present meeting as a face-to-face event, and for his continuing support to ASSAf.

Using the capacity at its disposal, ASSAf is considering how best to tackle the polycrisis. ASSAf would be using the theme of polycrisis as the 'mothership', bringing in the various topics as satellites, not in isolation but in an interdisciplinary way.

<u>Discussion</u>

Prof Burton explained that the DSI had been working on strategic plans and had developed the Decadal Plan for Science, Technology and Innovation as a guiding document for addressing the national priorities, which intersected to a large extent with the priorities that were being highlighted in the BRICS Academies Forum including developing a national hydrogen energy economy; considering renewable energy; agriculture in relation to climate change; modernising agriculture using the opportunities of digital science, data science, big data, AI and communication (which is especially important for small rural farmers in South Africa who tend to work in an isolated way); education; understanding the polycrisis impacts of climate change in the context of the importance of the broader society; and adopting new technologies in all areas of industry (which will require new skills and new understanding to take advantage of international developments to accelerate national development).

Prof Kalula observed that his role on the ASSAf Council was that of 'cheerleader'. He thanked ASSAf and the DSI for supporting the present gathering, and welcomed colleagues from the other BRICS Academies.

For Prof Kalula, the starting point is the integration of science. The presentations by the various academies showed a multifaceted and interdisciplinary understanding of science in society. ASSAf was called the Academy of Science (not Sciences) in the belief that science is integrated. Unless scientists understand this, the impact of science will be less profound. Prof Kalula commended all the BRICS academies for their multidimensional definition of science. He thanked the speakers for their clear expositions of the programmes, their aims, achievements and ongoing activities. The ability to present science in such an accessible way is critical for the communication strategy for science.

Beyond pitching for resources, engendering public trust and popularising science is one of the most important aspects of the role of an academy. Part of ASSAf's strategy, for example, is to engage with schools; unless this role is undertaken, the impact of science for society will be reduced, and the development of the next generation of scientists will be undermined. South Africa has an ageing cohort of worldclass scientists, who 'punch above their weight', but there is slow emergence of the new generation of scientists. The communication strategy is thus immensely important, and the role of the academy must include mentoring of young scientists and ensuring that the young generation is involved.

Collaboration in science has an impact at two levels: firstly, through exchanging experiences across academies and moving in tandem in terms of the universality of science; and secondly, by impressing upon government the importance of science in the context of the internal challenge of the lack of adequate resources. During the COVID-19 pandemic, the South African government had looked to scientists for advice and listened to what they were saying, which was one of the reasons why South Africa had fared better during the pandemic than some other countries.

It is important for ASSAf to learn what is happening elsewhere, and how different academies ensure that the state not only gives the academy the share of resources it deserves but also trusts science, appreciates its importance, and acknowledges the commitment of scientists to addressing the challenges facing society.

Prof Kalula cited the example of Senegal. During a visit to Senegal several years ago, when he had represented ASSAf at the annual meeting of the Senegal Academy of Science and Technology, for example, Prof Kalula had been impressed at how seriously the academy was taken by government. The academy is expected to take on national challenges and projects, drive the science, advise government and make recommendations. The reports on the outcome of such initiatives are presented to the country's president in person, and include not only the findings but also an implementation strategy.

International cooperation among scientists needs to look at the global South, which is an important role of the BRICS Academies. In the African context, ASSAf needs to be involved with projects of the African Academy of Sciences. ASSAf's approximately 30 staff ensure that the resources that the academy receives are properly used. The role of academies is also to look out for lesser academies, not just BRICS academies. This kind of approach will increase the impact of science on livelihoods and the possibility of utilising science as a solution to the polycrisis.

SESSION 3 (CHAIR: PROF HIMLA SOODYALL, EXECUTIVE OFFICER, ASSAf)

DISCUSSION: PROBLEM DEFINITION, SOLUTION SEEKING

Prof Soodyall introduced the session and invited engagement and discussion.

The Network of African Science Academies (NASAC) had been invited to participate in the BRICS Academies Forum, and to hold their board meeting in South Africa; however, due to the change of date to accommodate the request from the Brazilian Academy of Sciences and the Indian Academy of Sciences, NASAC had no longer been available. The intention had been to extend the dialogue among academics elsewhere on the African continent, and each academy had been invited to use the technical note to distribute key points for discussion during this session. ASSAf had circulated its technical note ahead of the BRICS Academies Forum meeting, but the other academies had not made use of the opportunity.

Prof Soodyall thanked the representatives from the academies represented at the present meeting for their punchy presentations, and the different approaches taken by each academy, with sufficient baseline information as the foundation for interactive engagement. The brief for the forum meeting mentioned the aim to understand the challenges each country represented among the BRICS Academies was experiencing, and to get insight into the problem definition.

COVID-19 was an example of a problem that all countries had faced. Each country had come up with a plan to deal with and mitigate the impact of the pandemic, and one of the intentions of the present forum was to identify any policies that had been put in place in this regard.

Lastly, the intention of the Forum was to explore what the individual academies were doing within the landscape to identify and address the issues. Against this background, the thematic agenda for the Forum meeting had been set. All the academies had interpreted the brief slightly differently, and had provided insightful information.

The task during the open discussion was to identify some of the major challenges across the board, and some that might be more prevalent in one region than in others.

Climate change is facing all countries, and the Forum had heard what the different countries were doing to address this. Prof Soodyall invited discussion of what the academies should collectively focus on.

Prof Mande observed, in relation to the challenge of climate change, that total greenhouse gas emissions in 2022 were an estimated 36.6 billion tons in 2022 (according to the Global Carbon Budget 2022), but the distribution differs across countries. The problem statement is clear, and needs to be addressed by all, but countries are adopting different solutions suitable for their particular needs. India is moving towards solar and ocean energy, and has a Ministry of New and Renewable Energy, the mandate of which is to ensure energy security, availability, affordability and equity, and to increase the share of clean power. The Indian cabinet approved the National Green Hydrogen Mission in January 2023, which aims to make India a leading producer and supplier of green hydrogen in the world. India was aiming for carbon neutrality by 2070, compared to certain other BRICS countries which had set the target at 2050. The Indian steel industry was aiming for carbon neutrality by 2043, and Tata Steel was taking steps to replace blast furnaces with renewable sources. The transport sector, especially in relation to large vehicles, could look to green energy to replace reliance on coal.

Prof Mande proposed that the BRICS Academies Forum should acknowledge that the solutions are different for different countries. The academies should discuss the solutions among themselves, identify which would be most suitable for different geographies and try to adopt these.

There had been a recent discussion at COP28 on food and agriculture. Prof Mande noted that food and agriculture account for about one quarter (25–27%) of the impact of CO_2 and methane emissions. The solutions could come from multiple angles including food levies, changes in agricultural practices and the use of certain chemicals and pesticides, and urging people to alter their food habits to keep emissions in check, although the latter would be a tall order. The solutions will differ from country to country.

Dr Maharaj observed that there were components in societal challenges to respond to, as very few people were involved in academies. This would force the academies to be deliberate in what they choose to focus on, and which niche constituencies they could focus on that would add value to other agencies participating in activities towards the same end. It was also important to realise that the BRICS Academies are contributing to a debate in which certain ideas move forward while others retreat, while some receive support and become the new 'buzz words'. Within this frame, the tools that countries use to measure themselves often come from benchmarks set by institutions in the global North, and other countries measure how far they are from the prescriptions of such reports.

Dr Maharaj recommended that BRICS+ should increasingly realise that they speak for the global majority, and must benchmark for themselves. Various institutions produce the quantities behind the planetary boundaries, which aim to define the environmental limits within which humanity can safely operate. This approach had proved influential in global sustainability policy development, but the safe space had been exceeded in six of the nine vectors. Monitoring of the planetary boundaries was not being done regularly enough. The BRICS Academies had the opportunity to develop a framework to determine whether they had positively contributed against the negative impacts of climate change.

A key point was the difficulty of obtaining comparable data from the five BRICS countries; for example, even the definition of a scientist is not uniform across the countries, making it impossible to compare the number of scientists active in the respective countries.

In a report on inequality in which Dr Maharaj had been involved, only three of the BRICS countries officially had inequality before 1994, since Russia and the People's Republic of China had not been measuring inequality. As the countries had worked together on the report and built up trust, they had started to measure how inequality was arising in their societies. Dr Maharaj proposed that there was scope to bring together young scientists from the ten countries that would be going forward in BRICS[6] and training them to staff structures such as the IPCC and lead debates.

There are a range of issues confronting the BRICS Academies, and it is not possible to address all of these. Dr Maharaj proposed that rather than trying to do many things inadequately, the academies should rather select a few targets to aim to achieve, and steer the necessary resources to make a success.

Dr Maharaj suggested a measure of energy poverty, whether for industrial or domestic purposes. In many instances, it might not be necessary to have the massive power plants that were available in the 20th century, and instead implementing numerous small, distributed power plants. Currently 650 million people are considered to be extremely energy poor,

[6] Egypt, Ethiopia, Iran, Saudi Arabia and the UAE will be joining BRICS on 1 January 2024.

without access to electricity, of whom over 450 million are in Africa. This could provide a starting point for demonstrating how the BRICS Academies are contributing to exchanges and to decreasing energy poverty.

Prof Jia referred to going beyond the sectoral approach, and the way in which Earth as a system will change if the planetary boundaries are exceeded. The World Climate Research Programme (WCRP) Open Science Conference in Rwanda in October 2023 was organising an open paper looking at the implications of global warming of 1.5°, 2° and 4° for Earth as a system. The fundamental changes to different sectors of reaching and exceeding the tipping point might be similar to polycrisis thinking, or possibly a balance could be struck at a different point. This was a research topic that the academies might consider undertaking.

Prof Kalmykov emphasised that people should trust academies as having an independent scientifically based view of topics, being separate from strict government restrictions and not linked to any large corporations. The balance is very important. Some sectors of the economy are targeted, for example fertilisers, construction and steel, but the modern state could not survive without the scientific economy. It also needs to be discussed how to concentrate greenhouse gases; for example, CO_2 could be concentrated using membranes and could serve as primary chemical reagents in fields such as pharmaceuticals. Concentrated CO_2 could be pumped to deep underground reservoirs that remain after the exploration of natural gas and oil. There are thus scientifically based ways to minimise and accept greenhouse gases from the atmosphere.

Prof Saha supported polycrisis as an important topic, being the net sum of all the crises facing humanity and hence an enhanced crisis. The BRICS Academies could join hands to eliminate the crisis, which could bring about big change in addressing the global polycrisis. New technologies enhanced by AI could be adopted to understand the climate changes across the world through the prevalence of hurricanes and heat maps, for example. The BRICS Academies could extend their own perspective and work together towards a global perspective. Geographically, the solutions will be different per country; it is important to understand the solutions that arise from different contexts and take the best solutions forward together.

Prof Mehra pointed out that most of the countries that would be joining BRICS are not members of the G20. The focus of BRICS in 2023 had been on issues including climate change, transformation of education and skills development. The BRICS Academies Forum should focus on science-based approaches to the issues of the polycrisis. He suggested developing a policy document with the focus not on geopolitical or economic issues but on science-based issues, including the global polycrisis and big data sharing. He suggested that the document should not be large otherwise there was the risk that it would not be read, but should give points on which science academies could work together.

Prof Fan raised the importance of science integrity and the challenge of new technologies.

Prof Soodyall invited suggestions of tangible issues that the BRICS Academies could take forward.

Prof Burton identified two kinds of themes that had been covered, and on which there was some common ground and agreement that they are challenges:

- **Energy–environment–economy nexus**
- **Human health and wellbeing related to environment, climate (e.g. climate-sensitive diseases)**

- **Agriculture, food security and using technology to modernise agriculture and make it more benign**
- **New technologies related to digitisation and AI, which applies to all the areas**
- **The role of academies in convening and bringing groups together, since the academies represent big communities in the various regions and have capacity for public engagement; communication, which could be shared; credibility that should be used for public trust; independence to some extent and hence the capacity to advise on policy; and capacity to manage, monitor and highlight research integrity**.

With respect to how the academies can implement initiatives, one approach would be to establish small working groups and develop working papers. Prof Burton would like to see bigger groups being engaged rather than just one or two representatives per academy. She supported producing a two-page document that was pragmatic, indicating what the academies intended to do within a defined timeline. Once agreement had been reached on the themes, the academies could agree on which colleagues to involve.

Prof Soodyall supported the proposal of five themes.

Prof Yan observed that the notion of polycrisis is too broad, and suggested that in order to make the document pragmatic, *the scope should be narrowed down in alignment with the topics and themes mentioned in the presentations*. He concurred that the academies should not touch issues of politics or geopolitics. *He suggested that the document should be entitled* '*Recommendation of scientific approaches to address polycrisis*'.

A statement from the BRICS Academies as an outcome of the present forum would be 'once-off'. China had signed a statement on big data sharing, for example, but it is difficult to turn such a statement into concrete actions. Prof Yan therefore suggested the establishment of a BRICS Academics journal to showcase what the academies are doing and thinking about as a regular channel to publish ideas on the polycrisis. He suggested that a journal would be more effective than just a once-off statement. He agreed on identifying a maximum of five themes for the BRICS Academies to address. The approach could be either philosophical or instrumental, and more scientists could become involved. The structure could possibly be similar to the Global Risk Report, although the content would be different, coming as the voice of the South not the North.

Prof Mehra agreed on focusing on four or five themes, which could possibly increase over time. He emphasised the interdependent nature of the polycrisis, the dynamics of which range from climate change to economic disparities and technological disruptions, with the human being in the centre. Education is a main theme for South Africa; a multidisciplinary approach could be considered to evolve a system of education. Climate change affects not only health but also energy transition (e.g. energy from the ocean and solar). Technological equity and access do not receive enough attention. Technology knows no boundaries, and a system of technology indices could be created. Prof Mehra suggested writing a paragraph under each of the themes in the form of a 4–5-line introduction on the topic and the areas where the academies could work together as a team.

Prof Naidoo proposed raising awareness of the state of the art of the key elements of the periodic table, teaching these to school learners and university students, and bringing the knowledge to the level of availability for all: for example: C (carbon economy), H (hydrogen economy) and U (uranium) economy. This would help develop momentum for how to go forward.

Prof Soodyall summarised the agreement reached on taking a thematic approach, using a succinct model to present a preamble about the nexus theme, articulating the idea of the interrelatedness of the themes, and perhaps incorporating a synthetic view from the academies represented at the forum of their interpretation of the problem statement.

When the additional countries join BRICS in January 2024, their science academies would be invited to join the BRICS Academies Forum. It was at this stage not clear how this discussion would be carried forward into the bigger group. There were only a few working days remaining in the current year to come up with a plan.

Prof Soodyall expressed the view that the suggestion for a BRICS Academies journal might be too complex to implement at present. Some of the academies already have their own journals that could be used to spread the message (e.g. ASSAf publishes the *South African Journal of Science*, which accepts papers among others on the theme of multidisciplinarity; submissions are considered by the editor on their merits). Dr Maharaj suggested requesting a special issue of the *SAJS* on the polycrisis, but Prof Soodyall noted that the *SAJS* had already commissioned the special issues planned for the following year. Prof Soodyall suggested that a blog among the academies might be considered as another forum for publicising the activities.

Prof Mehra commented that the *Proceedings of the Indian National Science Academy* could also be used to publish an article signed by the academies present at this forum to draw attention to the theme of polycrisis.

Prof Himla observed that a journal article gives more latitude than a statement in terms of wordcount to articulate the challenges and solutions; she endorsed the perspective that while the countries represented by the academies were experiencing similar challenges, the ways in which they respond are different. This allows learning from what other countries have done under similar scenarios; accessing data on which initiatives have worked and the extent to which they are successful; and for other countries to be able to consider whether these examples could be a feasible option for their own circumstances. The idea of sharing of experience comes to the fore, and Prof Soodyall suggested trying to articulate this in the article format.

RECOMMENDATIONS AND WAY FORWARD

The outcome of the Forum would be a two-page statement. It was emphasised that this would be the product of those present at this forum, which did not include the Brazilian Academy of Sciences, which had been invited to the forum meeting but had chosen not to participate. The statement would be produced for the information of the new BRICS Academies Forum structure.

ASSAf would publish a report on the 2023 BRICS Academies Forum meeting. This could be published in either the *South African Journal of Science* or the *Proceedings or the Indian National Science Academy*, possibly as a joint contribution. The report would cover the concept of the meeting, the theme, who participated and the highlights. Before submission, ASSAf would share the article with the other academies that had participated in the forum.

ASSAf was considering writing an article for submission to the *SAJS* on the thinking around the polycrisis, and the other academies indicated that they had no objection. Any other academy could publish a summary of their own presentation and other ideas that fit their brief. Any academy could do so without the need for consultation with the others.

The distinction between the two-page statement and the article in the *SAJS* was clarified, in order to avoid any misunderstanding between their differentiated purposes:

- The article would be a perspective and interpretation of the polycrisis, including an overview, record of what is being done, what is known, and what has happened.
- The statement should look forward to what needs to be done, as a roadmap that would be used to inform government departments and the new incoming BRICS Academy partners.

ASSAf as the host academy would produce the first draft of the statement. It was suggested that the first draft should be four to five pages long, which could be summarised to two pages in the final version. The joint communication would have to be consulted and approved by the governments of the respective academies.

Copies of the presentations would be shared among participants.

The way forward was agreed and summarised as follows:

Article to be published in South African Journal of Science (*SAJS*)- ASSAf –BRICS focused
Other academies may also follow suit with their perspective in their respective journal

Joint Document by the BRICS Academies Forum 2023
First draft by host academy, ASSAf
Circulated between the academies for input and once finalised send to the academies respective government departments (Should be 4–5 pages and will be summarised to 2 pages)

Themes identified
1. Energy, Environment and Economy (Energy Transition in Climate change era, Energy Poverty)
2. Human Health, Well Being and Climate Sensitivity (Climate sensitive diseases) (Human Health in Climate emergency
3. Nutrition, Agriculture and Food Security (Modernisation of Agriculture)
4. New technologies related to Digitalisation, Artificial Intelligence, Technology Equity and Access
5. The role of academies (Capacity to manage, monitor and highlight research integrity, Building public trust, Science Engagement, Multidisciplinary approaches to polycrisis, International Cooperation)
6. Education
7. Recommendations on Scientific Policy to Address Polycrisis

CLOSING REMARKS (PROF STEPHANIE BURTON, ACTING PRESIDENT, ASSAf)

Prof Burton recalled that the forum had begun by saying that it would take up from the previous BRICS Academies Forum (at which she had not been present). The present forum had made clear links with the previous one and had made progress with a new strategic focus and ideas, and had been very formative. The forum had started the previous evening (1 December) with the helpful outline presented by Dr Maharaj to guide the discussions.

The sessions on 2 December had then taken forward the ideas that had previously been shared, and which had developed and changed through the conversation. It had been useful to spend time together and arrive at consensus on the priorities to be taken forward. It had been hoped to have an implementable action plan and way forward by the end of the forum, and the academies present had made a start in that regard. Importantly, connections had been made and acquaintances forged. It was therefore valuable that the meeting had taken place in person. Prof Burton thanked the colleagues who have travelled from afar to attend.

The forum had been very worthwhile, and the ideas and plans that had been discussed, and the outcome of the meeting, would develop and grow. She trusted that everyone felt that their contribution had been taken into account. This was start of the initiative to inform governments and stakeholders. Prof Burton hoped the ramifications of the forum would be lasting and would inform next round of the BRICS Academies Forum meetings (when the participating academies would have increased to 11), and that the participants would look back on it as worthwhile.

Prof Burton thanked the ASSAf colleagues for their seamless organisation of the event. She had been Acting ASSAf President for two weeks, and found the system to be effective. This was the end of the academic year in South Africa before the summer holiday, and she wished everyone a rest over the recess at the end of a busy year.

The chairperson thanked everyone for their participation and closed the meeting at 16:10.

APPENDIX A: LIST OF ACRONYMS

AI	Artificial intelligence
AMR	Antimicrobial resistance
ASSAf	Academy of Science of South Africa
BIT	Beijing Institute of Technology
BRICS	Brazil, Russia, India, China, South Africa
CAS	Chinese Academy of Sciences
CNCF	Cloud Native Computing Foundation
COP	Conference of the Parties
COVID	Coronavirus disease
CT	Computed tomography
DSI	Department of Science and Innovation
GDP	Gross domestic product
GHG	Greenhouse gas
IAP	InterAcademy Partnership
INSA	Indian National Science Academy
IPCC	Intergovernmental Panel on Climate Change
MBIR	Multi-Purpose Fast Research Reactor
MIDI	Microwave Integrated Drought Index
MRI	Magnetic resonance imaging
MSU	Moscow State University
NASAC	Network of African Science Academies
NDC	Nationally determined contribution
NGO	Non-governmental organisation
ODA	Official development assistance
PM	Particulate matter
RAS	Russian Academy of Sciences
ROSATOM	Russian State Atomic Energy Corporation
SAJS	South African Journal of Science
SDG	Sustainable Development Goals
SMBU	Shenzhen MSU-BIT University
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
USA	United States of America
WHO	World Health Organization

APPENDIX B: LIST OF PARTICIPANTS

Academy of Science of South Africa
ASSAf Council
Prof Stephanie Burton
Prof Evance Rabbana Kalula

Technical team
Dr Rasigan Maharaj
Prof Caradee Wright
Prof Pat Naidoo

ASSAf Secretariat
Prof Himla Soodyall
Dr Melusi Thwala
Ms Susan Veldsman
Dr Tozama Qwebani
Ms Henriette Wagener
Mr Aluwani Ramulifho
Dr Khutso Phalane
Ms Raj Mahabeer
Dr Tebogo Mabotha
Mrs Marvin Mandiwana
Mr Ian Shendelana

Chinese Academy of Sciences
Prof Chunliang Fan
Prof Gensuo Jia
Prof Zhuang Yan

Indian National Science Academy
Prof Narinder Mehra
Prof Shekhar Mande
Prof Kasturi Saha

Russian Academy of Sciences
Prof Nikolaevich Stepan Kalmykov

APPENDIX C: TECHNICAL BRIEFING NOTE

BRICS ACADEMIES FORUM

Technical Briefing Note: "Inter-Academy Collaboration on Global Polycrisis"

Hosted by the
Academy of Science of South Africa (ASSAf) in partnership with
the Department of Science and Innovation (DSI),
South Africa

Date: 1-2 December 2023

Venue: Pretoria, Maslow Times Hotel, Menlyn

Background on Global Polycrisis

The United Nations gathered the various heads of states and governments in 2020 and proclaimed that "(o)ur world is not yet the world our founders envisaged 75 years ago" (UN, 2020). It is plagued by growing inequality, poverty, hunger, armed conflicts, terrorism, insecurity, climate change, and pandemics. People around the world are forced to make dangerous journeys in search of refuge and safety. The least developed countries are most affected by these challenges as some of them have not completely achieved independence from past colonial control. All this calls for "greater action, not less" (UN, 2020).

Various analyses of our contemporary conjuncture reveal a range of challenges and crises that confront our species-being in the second decade of the 21st century of our common era. Our increased capacities, capabilities, and competences in scientific and technological methodologies and praxis have served to expand our knowledge of the natural world and improve our understanding of the social shaping of such determinations. The philosophers and sociologists Edgar Morin and Anne Brigitte Kern (1999) eschewed hubris and acknowledged that we are "… at a loss to single out a number one problem to which all others would be subordinated. There is no 'single vital problem,' but many vital problems, and it is this complex inter-solidarity of problems, 'antagonisms', crises, uncontrolled processes, and the general crisis of the planet that constitutes the number one vital problem" (Morin and Kern, 1999).

Swilling (2013), a pioneering South African intellectual and a Commissioner in the National Planning Commission (South Africa), has contributed significantly to the sustainable development literature, built upon the work of Morin and Kern (1999), and cogently defined the concept of polycrisis as "… a nested set of globally interactive socio-economic, ecological and cultural–institutional crises that defy reduction to a single cause" (Swilling, 2013). The economic historian Tooze (2022) helped popularise the concept in his column in the Financial Times which was entitled: 'Welcome to the world of the polycrisis' in 2022. Tooze (2022) reminded us that: in the polycrisis, the shocks are disparate, but they interact so that the whole is even more overwhelming than the sum of the parts". In a recent update and pleading for the urgent need for further research, Thomas Homer-Dixon amongst others argues that the global polycrisis should be recognised as "a single, macro-crisis of interconnected, runaway failures of Earth's vital natural and social systems that irreversibly degrades humanity's prospects" (Tooze, 2022).

It is on the basis of this critical analytical concept that the scholarly academies of Brazil, Russia, India, China, and South Africa will convene during the BRICS Academies Forum 2023 to share their respective work in understanding the polycrisis and enabling deeper collaboration amongst them through shared and common monitoring, evaluating, and learning interventions which seek to reduce the chasm between the peoples of the BRICS countries and their national systems of innovation whilst contributing solutions and co-constructing a just and multipolar world that works for all. Resonant articulations of the world polycrisis now abound ranging across from multilateral institutions such as the United Nations, global civil society such as the International Trade Union Confederation, and business associations such as the World Economic Forum.

Common Stresses and Systemic Synchronization

Many global systems are currently undergoing radical change; this simultaneity of change is probably not coincidental. It suggests common stresses are causing synchronization of underlying system behaviour, which may account (at least in part) for the acceleration, amplification, and apparent synchronization of today's global crises.

- The **environmental system** is leaving its Holocene equilibrium and entering a period of instability due to anthropogenic disturbance of the climate and other physical and ecological systems (Armstrong *et al*., 2022) – the current period being increasingly reflective of the human footprint. This instability is already causing enormous human harm, and its effects could become catastrophic in the near future (Hall, 2018).
- The **global energy system** has begun to decarbonize, shifting away from fossil fuels, although uncertainty remains around achievement of zero-carbon energy system. The socio-economic and environmental of the shift is also uncertain, hence the question of whether it is just for everyone? (Allison, 2017).
- **The global economic system** is shifting from a neoliberal economic regime—one undermining itself through worsening instability, inequality, and ecospheric externalities—to a yet indeterminate regime, but one likely involving increased dirigisme and economic integration within ideological blocs (Rodrik and Dani, 2011).
- **The information technology system** is being revolutionized by artificial intelligence, with unclear but likely unprecedented implications for employment, decision making, and personal, national, and global security (Lawrence *et al*. 2023).

The response by BRICS Academies of Science

Accelerated climate change, enduring energy challenges, poverty, and the persistence of socio-economic inequalities are amongst the most prescient global challenges that demands our collective attention and creativities for the betterment of society and our planet. The BRICS Academies Forum provides an opportunity for the five academies to engage on how the BRICS member States recognise global polycrisis and the processes advanced to ensure that their respective science, technology, and innovation (STI) systems are capacitated and capable of providing evidence-based solutions to secure a better future for all. It is hoped that these discussions can lead to a proposal for a BRICS Inter-Academy Working Group on Global Crises to encourage academic collaboration and cooperation amongst the BRICS Academies going forward.

The BRICS Academies Forum is an opportunity to lead the globe by providing strategies to address the polycrisis through discussion on the following objectives:

(i) Academic consensus on defining the global polycrisis.
(ii) Inter-Academy knowledge and praxis sharing on solution seeking, prioritization, and financial resourcing.
(iii) Intra-Academy research collaboration on monitoring, evaluating, and learning.

Format of BRICS Academies engagement on polycrisis:

Foundation Matrix Framework

	Ecology (e.g., Climate Change and the Environment)	Economy (e.g., Indebtedness and Austerities)	Society (e.g., Inequalities and social distress)	Governance (e.g., lack of international coordination)
Problem Definition	What are the discrete crises that constitute the polycrisis in respective national systems of innovation?			
Solution Seeking	What Solutions are emerging to respond to the polycrisis?			
Prioritisation and Budgeting	What criteria informs the identification and prioritisation of various aspects of the polycrisis? How are public resources such as Budgets influenced by the polycrisis?			
Monitoring, Evaluating, and Learning	How are various aspects of the polycrisis being Monitored and Evaluated? How are the M&E results utilised in diffusing Learning across various actors and stakeholders in National Systems of Innovation?			

STEP 1: Compilation, collation, and sharing of experiences by the five National Academies to be submitted to ASSAf prior to the BRICS Academies Forum session as guided by the Foundation Matrix Framework by **20 November 2023**.

STEP 2: Presentation by each BRICS Academy during the BRICS Academies Forum closed session according to Chatham House Rules (participants are free to use the information received, but neither the identity nor the affiliation of the speaker(s), nor that of any other participant, may be revealed) to encourage inclusive, open, and critical dialogue amongst the participants. In addition to aligning to the proposed **Foundation Matrix Framework**, the presentations can engage on for instance; challenges associated, proposed solutions (*low hanging fruits*), how this crisis may potentially affect the BRICS network and what policy considerations could be recommended.

Proposed outputs of the 2023 BRICS Academies Forum Meeting

It is hoped that the following outcomes could be realised from this meeting

1. Issuing a BRICS Academy Statement/Declaration on Global Polycrisis after the meeting.
2. Establish the BRICS Academies Working Group on Global Polycrisis (rotational chairing and secretariat).

References

Allison, G.T. 2017. Destined for War: Can America and China Escape Thucydides's Trap? Melbourne London: Scribe Publications.

Armstrong McKay, David I., Arie Staal, Jesse F. Abrams, Ricarda Winkelmann, Boris Sakschewski, Sina Loriani, Ingo Fetzer, Sarah E. Cornell, Johan Rockström, and Timothy M. Lenton. 2022. 'Exceeding 1.5°C Global Warming Could Trigger Multiple Climate Tipping Points'. Science 377(6611): eabn7950. doi: 10.1126/science. abn7950.

Baum, S. D., and Barrett A. M. 2018. 'Towards an Integrated Assessment of Global Catastrophic Risk'. Pp. 41–62 in Proceedings of the First International Colloquium on Catastrophic and Existential Risk. Garrick Institute for the Risk Sciences, University of California, Los Angeles.

Hall, C.A.S. 2018. Energy Return on Investment: A Unifying Principle for Biology, Economics, and Sustainability. Cham, Switzerland: Springer.

Homer-Dixon, T., Renn, O., Rockstrom, J., Donges, J.F., Janzwood, S. 2022. A call for an international research program on the risk of a global polycrisis. Technical Paper 2022-3, version 2.0. Cascade Institute.

Lawrence, M., T. Homer-Dixon, S. Janzwood, J. Rockström, O. Renn, and J. F. Donges. 2023. "Global Polycrisis: The causal mechanisms of crisis entanglement." Version 1.0. Pre-print. Cascade Institute. https://cascadeinstitute.org/technical-paper/global-polycrisis-the-causal-mechanisms-of-crisis-entanglement/

Morin, E., Kern, A.E. 1999. Homeland Earth: A Manifesto for the new Millenium. Hampton Press, New Jersey, USA.

Rodrik, Dani. 2011. The Globalization Paradox: Democracy and the Future of the World Economy. New York: W. W. Norton & Co.

Swilling, M. 2013. Economic crisis, long waves and the sustainability transition: An African perspective. *Environmental Innovation and Societal Transitions*, 6: 96–11.

Tooze, A. 2022. Welcome to the world of the polycrisis. Financial Times, 28 October 2022. https://www.ft.com/content/498398e7-11b1-494b-9cd3-6d669dc3de33

United Nations. 2020. Declaration on the commemoration of the seventy-fifth anniversary of the United Nations. A/75/L.1