ANNUAL MEETING OF AFRICAN SCIENCE ACADEMIES (AMASA) 2022

'Strengthening Capacity for Sustainable Agriculture and Food Systems in Africa'

Report

Participants during the Annual Meeting of African Science Academies (AMASA) 2022

Nairobi-Kenya 28th – 30th November, 2022

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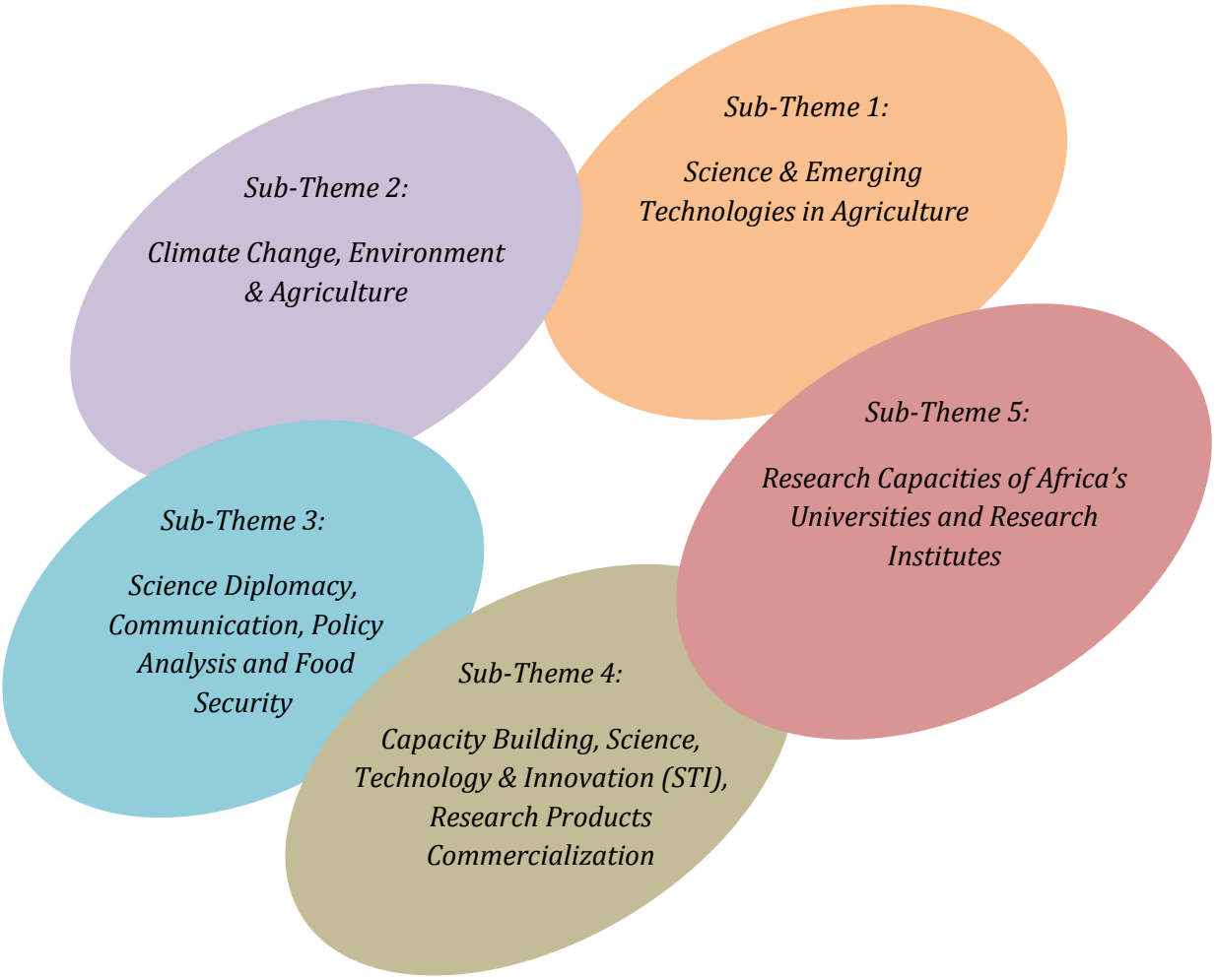
CONFERENCE SUB-THEMES



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ACRONYMS AND ABBREVIATIONS

AATF	African Agricultural Technology Foundation
AMASA	Annual Meeting of African Science Academies
APHRC	Africa Population and Health Research Center
AR	Assessment Report
AUDANEPAD	African Union Development Agency - New Partnership for Africa's Development
BAS	Botswana Academy of Science
BMGF	Bill and Melinda Gates Foundation
BSAB	Biosafety Appeals Board
CARTA	Consortium of Advanced Research Training in Africa
CAS	Cameroon Academy of Sciences
CSA	Climate Smart Agriculture

DRST	Direct in or of Research Science and Technology
EIDM	Evidence Informed Decision Making
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GET	Gene Editing Technology
GHGs	Green-House Gasses
GM	Genetically Modified
GMO	Genetically Modified Organisms
ICT	Information, Communication Technology
ILRI	International Livestock Research Institute
INGSA	International Network for Governmental Science Advice
IPCC	Intergovernmental Panel on Climate Change

IPR	Intellectual Property Rights
IR	Implementation of Research
ISAAA	International Service for the Acquisition of Agri-Biotech Applications
KALRO	Kenya Agricultural & Livestock Research Organisation
KEFRI	Kenya Forestry Research Institute
KNAS	Kenya National Academy of Sciences
LAST	Lesotho Academy of Science and Technology
LMICs	Low and Middle Income Countries
MAST	Mauritius Academy of Science and Technology
MMUST	Masinde Muliro University of Science and Technology
MOE	Ministry of Education
MUT	Murang'a University of Technology

NACOSTI	National Commission for Science, Technology and Innovation
NASAC	Network of African Science Academies
NCPB	National Cereals and Produce Board
NRF	National Research Fund
RAS	Rwanda Academy of Sciences
SADC	Southern Africa Development Community
SDGs	Sustainable Development Goals
SDUER	State Department of University Education and Research
SEI	Stockholm Environment Institute
SNAS	Sudan National Academy of Sciences
STI	Science, Technology and Innovation
TASAL	Tunisian Academy of Sciences, Arts and Literature

TIMPs	Technologies, Innovations and Management Practices
TUK	Technical University of Kenya
UAVs	Unmanned Aerial Vehicles
UON	University of Nairobi
ZaAS	Zambia Academy of Sciences

ACKNOWLEDGEMENTS

The AMASA 2022 Conference in Nairobi was hosted by the Kenya National Academy of Sciences (KNAS) in collaboration with the Network of African Science Academies (NASAC). The event was held in partnership with the African Population and Health Research Center (APHRC), International Network for the Acquisition of Agri-biotech Applications (ISAAA) and International Network for Government Science Advice (INGSA). The funding of the conference was from APHRC, National Research Fund (NRF), National Commission for Science, Technology and Innovation (NACOSTI), Stockholm Environment Institute (SEI), ISAAA-AfriCenter, and Biosafety Appeals Board (BSAB). As the AMASA 2022 Organizing Committee, we wish to extend our heartfelt gratitude to these institutions for the technical and financial support that made the conference a success.

The conference covered a broad set of topical issues on agricultural development and food systems in Africa that required the expertise of many experts who generously offered their time and insights. We wish to thank the presenters and authors for their contributions that made the conference memorable. In addition, we want to extend our appreciation to the discussants/panelists and rapporteurs for their contributions.

We also owe a debt of gratitude to the AMASA 2022 conference report writing team for their sacrifice in compiling this report in good time. The report was copyedited and proof-read by the editorial team at KNAS.

The secretariat at KNAS and NASAC are also acknowledged for their proficiency in planning and providing logistical support during the conference. The role played by the local organizing committee in the planning and conducting the conference is also highly appreciated. The AMASA 2022 Organizing Committee members worked very tirelessly in ensuring the success of this conference. To the members of the committee we say thank you for the support.

Prof. Vasey Mwaja, PhD, MKNAS, FRSB
Editor-in-Chief, KNAS
On Behalf of AMASA 2022 Organizing Committee

FOREWORD

African agriculture is critically important both socially and economically. However, it faces many challenges in ensuring food and nutrition security for a growing population in the face of global climate change and structural changes in land use and management. It has long been recognized that Africa needs to significantly and sustainably intensify its agricultural production. Low productivity farming has failed to keep pace with food demands due to rising population. But achieving sustainable increases in agricultural productivity is not easy as erratic rainfall, poor soil fertility and lack of infrastructure and support services offer limited prospects. This is made worse due to lack of incentives for farmers to invest in boosting productivity.

A better understanding of current and evolving conditions on how to increase productivity should aid in tailoring more pragmatic solutions for the farmers. The presenters and contributors to the AMASA 2022 conference which was held in Nairobi shared a belief that better understanding of the agricultural systems research and development in Africa can contribute to better targeted policy and investment decisions for the rural poor. There is also growing concern about the ability of African agriculture research and development (R&D) systems to respond to current and emerging challenges.

The Nairobi conference brought together a wide range of agricultural stakeholders from across Africa to discuss the challenges facing farming communities. The delegates discussed the latest ideas, appropriate solutions, and technologies that will promote sustainable agriculture and food systems in the continent. The outcome of the AMASA 2022 conference will hopefully boost Africa's capacity to sustainably meet food and nutrition security for the growing population. Deliberations will enable the continent to trade better within itself and internationally.

Modernized technology-led interventions that include utilization of biotechnology tools present huge prospects for improved agricultural productivity and growth of agricultural enterprises. In addition, the need and opportunity to improve agricultural productivity will require synergy with other related investments particularly in setting an enabling policy environment and enhancing scientists' technical and communication capacity. Policy makers in African countries need good data to inform their decision-making. Therefore, the national science academies in Africa should continue to support data collection, research and policy analysis related to better agricultural development and food systems in the continent.

Prof. Ratemo W. Michieka, Emeritus, Ph.D., FKNAS, MCIArb
Chairman, KNAS

EXECUTIVE SUMMARY

Agricultural productivity is an important indicator of economic performance of most African countries; with increased productivity and competitiveness enabling countries to feed their people, export more of their agricultural output to earn foreign exchange and create employment.

Raising agricultural productivity and reducing the yield gap of agricultural enterprises in Africa requires use of modernized technology-led interventions that include biotechnology. This can only be achieved through creation of synergy with other related investments particularly setting an enabling policy environment, capacity building and communication. The science academies and research institutions in the continent endeavour to promote technology-led investments in agriculture by strengthening integrated skills development and entrepreneurial capacity to stimulate commercial financing in agriculture.

It is with this understanding that the Annual Meeting of African Science Academies (AMASA) hosted a conference in Nairobi under the auspices of Kenya National Academy of Sciences in collaboration with the Network of African Science Academies, the Africa Population and Health Research Centre, International Service for the Acquisition of Agri-biotech Applications, AfriCenter and International Network for Government Science Advice (INGSA).

The conference brought together representatives drawn from African Science Academies, Governments, African Union, private sector, development organizations, academic and research institutions, etc., across Africa and the world to discuss the latest ideas and appropriate solutions and technologies crucial to boost Africa's capacity to sustainably meet the food and nutrition security needs of its population.

The five sub-themes covered by the conference included (i) science and emerging technologies in agriculture; (ii) climate change, environment and agriculture; (iii) science diplomacy, communication, policy analysis and food security (iv) capacity building, science, technology and innovation and research product commercialization in agriculture; and (v) research capacities of Africa's universities and research institutes. This conference was achieved through thematic keynote speeches, presentations, posters, group discussions, and panel discussions.

It was recommended that the National Academy of Sciences should become a platform to spearhead the African research agenda/ecosystem to coordinate research- science- policy interface; networks and partnerships including creation research matching platforms online with institutional and individual profiles, capacity strengthening: writing of award winning proposals, creation of national innovation hubs and commercialization of its products.

Greater visibility is needed for African researchers, academic and research institutions as generators of research evidence and innovations and drivers of adoption of research evidence for

decision making and policy changes. A more enabling Implementation Research and R&D environment for African women and men academics and early career researchers through the establishment of learning, support, and networking platforms is needed. As already stipulated by the African Union, the governments in Africa should contribute about 2% of their total annual gross domestic product to realize the agenda 2063, of which part of it can be disbursed to the national academy of sciences to expedite research, science, technology and innovations.

WELCOME SPEECHES

Remarks by Prof. Ratemo W. Michieka, Emeritus, FKNAS, MCIArb, Chairman KNAS

Prof. Ratemo W. Michieka, the Chairman of Kenya National Academy of Sciences, welcomed the delegates to Kenya and presented a brief on the role and function of the Academy. He highlighted the rich history of the then East African Academy of Sciences from 1962 when it was headquartered in Nairobi under the auspices of the then powerful East African Community. After the break of the community, the government of Kenya established the KNAS on 2nd November 1983.

The responsibilities of the Academy include among others: creating and carrying out maintenance of knowledge, informing policies, and engaging in capacity building. It also advises the government, establishes and maintains associations and linkages amongst scientists, organizes and collaborates in organizing scientific meetings, provides guidance to sources of scientific information, publishes and disseminates scientific information, and undertakes any other research portfolio consistent with other national academies.

Prof. Michieka recapped the importance of the national academies in driving the economic development in the continent. He emphasized the vital roles played by the academies in science, technology and innovation. He further emphasized that developed nations take their national academies seriously as they form country policies. Prof. Michieka finished his remarks by wishing the delegates a happy stay in Nairobi and advised them to take a day to visit the beautiful parks of Kenya.

Remarks by Prof. Norbert Hounkonnou, President, NASAC

The 2022 Annual Meeting of African Science Academies (AMASA-2022);

Distinguished delegates and guests, Dear colleagues; It is my pleasure to welcome you to the 2022 annual meeting of the African Science Academies in this majestic conference room of the Nairobi Safari Club Hotel. My joy is immense and overflowing because the hybrid character of this meeting is imposed by our own budgetary constraints and schedules, and not by the COVID-19 pandemic with such disastrous consequences for the human species already confronted with the complexity of many contemporary challenges.

NASAC is a consortium of 28 merit-based science academies in Africa and aspires to make the "**voice of science**" heard by policy and decision makers within Africa and worldwide. Academies are independent, highly committed, merit-based institutions, with members peer reviewed and selected from among the leading scientists predominantly in their countries that

recognize and promote excellence and achievement, and work together on wide-ranging public policy issues, free of vested political and commercial interests.

Today in Africa, in addition to well-established renowned national academies that work together through NASAC on issues of vital national and regional importance, there exist national young academies for early career researchers who are committed to science serving society. Many of our members work closely with their respective young academies.

Indeed, strengthening Africa's capacity to sustainably meet the food and nutrition security for the growing population enables the continent to trade better within itself. Indeed, most African economies still remain agrarian, in a context where the population is projected to exceed 9 billion by 2050 with persisting absolute high levels of hunger and undernourishment, making Africa the most food-insecure continent.

The basic pathway to attain 'the Africa we want' in the African Union's Agenda 2063 is mainly hinged on mastering a modern agriculture with well adapted relevant technology supported by appropriate policy. To paraphrase a brother and friend, Academician Doctor Papa Abdoulaye Seck, former Minister of Agriculture, Ambassador of Senegal to Italy, world-renowned specialist in agriculture, "the agriculture of tomorrow must result from a combination of 9 criteria: productivity, sanitary quality, phytosanitary quality, organoleptic quality, and spreading of production over time, spreading of production over space, management of natural resources, climate change resilience and diversification.

In the new civilizations, the emphasis is not only on productivity. I agree with him when he persists and signs: "no universal agricultural model." It is the realities on the ground that must serve as a compass because a made-to-measure tailor is always more precise than a ready-to-wear tailor.

Taking into account the heterogeneity of production, transfer and consumption systems and ecosystems is essential for success in agriculture. Africa can indeed be the future for agriculture. It must understand "that we do not eat the potential" and create innovation or ecology of innovation. In other words, it is necessary to transform the partnership into rural shareholding with a view to optimal exploitation of the complementarities between actors, expression of a common desire for a positive and sustainable transformation of African agriculture.

As NASAC continues to promote the voice of science to be heard by decision-makers and policy-makers in the continent and beyond, you can count on our determination. In partnership with other like-minded organizations, NASAC is ready to strategically cooperate to lend our voices to demanding science-informed sustainable agriculture in Africa. Science literacy and diplomacy should be integral parts of our campaign of extending knowledge and understanding

of scientific concepts and processes to society at large. This makes it a valuable tool for decision making, participation in civic and cultural affairs, and contributing to economic productivity.

We extend our thanks to the Kenya National Academy of Sciences, its Chair, Prof. Ratemo Michieka, all members of the AMASA 2022 Organizing Committee and Secretariat, our distinguished guests, to all keynote speakers, panelists, moderators, NASAC Executive Director Jackie Kado, NASAC Secretariat staff, and all attendees.

We look forward to your valuable contributions to the discussions.

Remarks by Amb. Simon Nabukwesi, Principal Secretary Ministry of Education, State Department for University Education and Research (MESDUER)

The President, Network of African Science Academies (NASAC), Prof. Norbert Hounkonnou;

The Chairman, Kenya National Academy of Sciences Prof. Ratemo Michieka; The Presidents of National Academies represented in the conference; Ladies and Gentlemen:

I'm greatly honored to have been invited to address you today on the occasion of your AMASA 2022 meeting and conference of African Science Academies in Nairobi. I am informed that this important gathering is meeting in Nairobi for the third time and that the first conference took place here in 2005.

The theme of AMASA 2022 conference: "Strengthening Capacity for Sustainable Agriculture and Food Systems in Africa" is well befitting the challenges faced by many countries in Africa on food security. The challenges in the continent emanate from limited use of modern technology in agricultural production. This has resulted in poor agricultural productivity and declined crop and livestock yields.

The Nairobi meeting has brought together representatives from African Science Academies, Governments, private sectors, development organizations, research institutions, from across the continent and the world to discuss the latest ideas and appropriate solutions and technologies.

The outcome of the AMASA 2022 conference will boost Africa's capacity to sustainably meet the food and nutrition security for the growing population and enable the continent to trade better within itself and into regional and international markets. The three-day conference will provide the opportunity for the delegates to discuss the challenges facing agriculture development and recommend the way forward for sustainable agriculture.

This gathering provides the opportunity for Africa to achieve this objective and your countries are expecting you to play an active role in achieving it. To use Kenya as an example; with

recurrent droughts over 10 million Kenyans are chronically food insecure and this number will increase in the traditional food production set-up. Hence the need to urgently change the way agriculture production has been done in the past.

The conference will discuss various sub-themes: Science and emerging technologies in agriculture; Climate change, environment and agriculture; Science diplomacy, communication, and policy analysis; Capacity building, science, technology & innovation and research products commercialization; and Research capacities of Africa's universities and research institutes. With the modern ICT, agricultural, manufacturing technologies that are being promoted globally, it is time for you to take leadership and create opportunities for the African farmers. This means using available knowledge to develop or apply the innovative technologies needed for higher yields, reducing food losses and wastage through agro- processing.

Without any doubt, Africa needs science-driven agricultural productivity, focusing on the needs of the poor grassroots communities and that technology and innovation would play a role to solve the agricultural and food crisis in the continent. Your organization has the capacity to promote and deliver sustainable agricultural solutions to improve food security and raise the incomes of small scale, rural farmer communities while ensuring healthy rural populations through access to better nutrition and healthy lifestyles.

Before concluding my remarks, I want to thank the organizers of AMASA 2022 Conference for actively engaging local partners during the preparation of this meeting. Let me wish you all fruitful deliberations during the 3 day conference. I also want to encourage our visitors to take a moment and visit our country and enjoy Kenya's hospitality. Nairobi City is a unique city with a National Game Park nearby for visiting guests to take time and experience Kenya's wildlife. With these remarks I now declare the AMASA 2022 Conference officially open.

Thank you.

BACKGROUND

Agriculture is the backbone of the economies of most African countries ranging between 30-60% to their Gross Domestic Product (GDP) (Saleh, 2022), export earnings and indirectly through links with manufacturing, distribution, and service-related sectors. Also, the achievement of food and nutrition security of the people in the continent depends on the agricultural sector, especially during this period of increased demand for food due to the growing world population. Approximately 140 million people in Sub-Saharan Africa are food and nutrition insecure due to declined agricultural productivity in the rural areas where a large population lives.

Food and Agriculture Organization (http://fao.org/3/al936e00.pdf) categorized food insecurity as follows: (i) acute food insecurity - which refers to severe hunger and malnutrition that could be fatal; (ii) occasional food insecurity-whereby food insecurity happens due to temporary circumstances, and lastly (iii) chronic food insecurity- which refers to the permanent threats to a peoples' ability to access food in sufficient quantities.

Previous studies have outlined the limitations towards the attainment of food security in Africa to include inter-alia: (i) war and political instability, (ii) migration and urbanization, (iii) population growth, (iv) poor agricultural sector policies, (v) climate change (vi) global price shocks affecting countries mostly in Eastern and Southern Africa including volatility in commodity markets, increases in energy and fertilizer prices, trade disruptions, and the ongoing events unfolding in Ukraine, (vii) unsustainable food systems and (viii) weak research, human and institutional capacities. For instance, locally led research is critical for overcoming global challenges in low and middle income countries (LMICs) (Dye, Reeder, & Terry, 2013). In order to achieve sustainable development outcomes in Africa, African institutions and individuals should take the lead in providing solutions to local problems (Ezeh, et al., 2019).

Despite years of investment in capacity building, Africa still lags behind in terms of capacity, research outputs and government investments, hence new dynamic and transformative models for building institutional and human capacities are needed (Ezeh, et al., 2019). There is increasing consensus that stronger research systems and capacities are the key to achieving improved food security in Africa.

However, the dilemma is that there is no consensus on the modalities of addressing these gaps. Part of the challenge is to get existing and emerging knowledge and skills about more (and less) effective strategies into practice. The evidence base also remains remarkably weak, partly because the research system has an image problem (Travis, et al., 2004) due to limited interaction between science and policy.

Therefore, strengthening research systems goes beyond filling immediate gaps to improve short-term outcomes. It aims at creating a health system that can adapt and respond to diverse challenges including epidemics, financial crises and other external challenges (Okereke and Bradshaw, 2022).

There are opportunities for sustainable and resilient food systems in Africa to address food security and nutrition challenges. The main elements for building resilience and sustainability into Africa's food systems include: (i) efficient use of nutrients and water; (ii) improved soil health; (iii) use of high-yielding, climate stress-tolerant seeds adapted to local climate change; (iv) crop diversification; and (v) investments in risk mitigation and management strategies (AGRA, 2021).

The actions that are required from all stakeholders to build resilience and sustainability into Africa's food systems include:

(i) Providing incentives for farmers to increase adoption of innovation that address local challenges;

(ii) Improving soil nutrient and water use efficiency;

(iii) Creating conducive policy and regulatory environments for sustainable and resilient food systems;

(iv) Increasing funding to agriculture research development and extension; and

(v) Prioritizing policy actions that enhance synergies.

Possible Solutions to Food Insecurity in Africa:

(i) **Enhancement of Intra-African trade** to strengthen food security on the continent. The continent is now looking for an alternative policy response to the ongoing war in Ukraine befitting the gravity of the situation.

One solution is to increase intra-African trade as a way to raise the resilience of the domestic and regional food market shocks for regional value chains and seek alternative countries from where imported food can be sourced. Therefore, investments are needed not only along the several stages of the value chain for the three major crops; maize, wheat and rice, but also in research and development for Africa's crops; roots, tubers, fruits and vegetables, which have received less attention.

(ii) Empowering Women - Most of the farm work in Africa is performed by women: who not only produce the food but they are already overworked with bringing up children. This situation is made worse as the youth migrate in hordes to cities and urban areas seeking for scarce

employment. Agriculture therefore is left to the aged ailing farmers whose capacity to produce food beyond subsistence quantities is decreasing. To this end, women empowerment in all areas of support is necessary especially financial, planting materials, and health facilities. Unless new methodologies for agricultural production are evolved, food production shall be diminishing; hunger, malnutrition and famine shall continue unabated.

(ii) Incentivization of the Youths: Perhaps substantial farm labour payments and agricultural subsidies will entice the youth to reconsider their rural-urban migration appetite and remain in the farms. Also, the use of modern emerging technologies will have a marked impact on the youth who would love to utilize artificial intelligence or the latest innovations for agricultural production. Laborious demand for production discourages the youth who shy away from such conditions.

(iii) Promotion of Agricultural Adult Literacy: The adult literacy rate in sub-Saharan Africa is around 63% meaning that one in three adults in the region or some 182 million people cannot read and write. Also while some African countries have higher literacy rates, many are actually lower; for instance South Sudan's 35% literacy rate is among the lowest in the world.

(iv) Promoting adult literacy, both via Governments and Non Governmental Organizations (NGOs) leads to more educated adults across Africa, which has positive, long-term effects related to food, nutrition and families. The importance of adult literacy can guarantee healthy living, safety of various food additives and use of excess pesticides.

(v) Direct Provision of Resources to Farmers: No matter where they are in the world, farmers need resources of all kinds; from education and funds to help purchase seeds, nutrients and supplies. Providing resources directly to farmers is one of the fastest ways to improve their conditions and increase crop yields, as well as the health and nutrition of their families and communities.

(vi) Build Climate-Smart Food Systems: Food Security is defined as a situation when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (United Nations Committee on Food Security).

Africa has multiple food systems challenges that are leading to clear multiple burdens of malnutrition; i.e., high prevalence of micronutrient deficiencies; diet related non-communicable diseases (diabetes and high blood pressure, etc). Additionally, with Africa's agriculture being mainly rain-fed, it is increasingly vulnerable to erratic and extreme weather including prolonged droughts and flooding which are increasing in frequency and intensity with the climate change.

However, there are opportunities that can be leveraged for food systems transformation to bring about positive change. It will take addressing different capacities; human, institutional, research and investment to support the needed transformation.

The transformation of agricultural research and delivery of services to improve productivity, risk management and investment decisions (at multiple scales) in Africa's farming systems require scientific research input. This transformation will be achieved through the following interventions but not limited to:

(i) Application of location-specific predictive crop and livestock management by 'last-mile' service providers informed by crop and livestock and farming system management/ decision support tools;

(ii) Science communication to the public; and

(iii) Capacity building of younger scientists in innovative agricultural systems to institutionalize change, strengthening of extension services, supporting crops and livestock production as a means of nutrition satisfaction.

The promotion of agricultural growth must nevertheless be done in a manner that limits environmental damage. This will also require promoting climate smart agriculture (CSA) in order to achieve the following: (i) sustainably increasing agricultural productivity and farm incomes; (ii) adopting agricultural systems and building resilience to climate change; and (iii) reducing greenhouse gasses (GHS) emissions in agricultural systems.

As issues of food security and nutrition are critical to Africa's well being, the debate on Genetically Modified Organisms (GMO) foods is gaining traction with lots of both political and scientific overtones. The public is constantly informed that genetically modified (GM) crops and foods are needed to feed the world's growing population and to meet the challenges that face farmers like climate change as well as pests and diseases.

It is claimed by pro-GMO supporters that GM crops will make agriculture more sustainable, giving higher yields, reducing pesticide use, and providing more nutritious food. GM foods are said to be as safe as non-GMO foods. The questions that the African continent and its governments should be asking include: *"Have we already optimized the existing technologies in the food systems before taking up new technologies?" Have the small scale farmers in Africa achieved the possible maximum output while using the existing technologies? If not, what is preventing them?*

There is no GM crop or food that has sustainably delivered the hyped benefits. At best, GM crops in Sub-Saharan Africa have performed no better than non-GM crops. At worst, they have introduced new risks into food and farming or exacerbated existing problems. Studies point to potential and actual harm to animal and human health and the environment from GM crops and the foods derived from them (MAghari and Ardekani, 2011). Further, there are concerns raised over ownership of planting materials including seed and possible pollen contamination of non-GM crops. Now the same claims are being made for a new generation of "gene-edited" GM crops as were made for the first generation. However, the GM crops have also been indicated to have potential advantages in terms of raising agricultural productivity and reducing the need for synthetic pesticides.

The concerns raised about the GM crops if true will equal food slavery especially in the African continent; hence it requires research evidence that is conducted, developed and approved for production in Africa by Africans. Thus, if scientists fail to enter important public debates, either individually or collectively, the vacuum may be filled by misinformation and lobbying from those with sectional interests. The National Science Academies should be proactively engaged in such activities.

In the current dispensation, the basic economic resource is no longer capital, nor land nor labour but knowledge. *Does Africa have the intellectual capacity to deal with emerging food and nutrition challenges?* Whatever the answer, the African scientific community must continue to promote broader public understanding of these issues at stake, work to improve the interface between scientists and policy-makers at all levels of governance and adapt and improve the utility of science systems, agriculture included, in supporting beneficial change.

What is needed in Africa are drought-resistant, productive, and disease-resistant agricultural systems that function as an integrated whole. This system can be achieved through research capacity strengthening. Most of existing interventions have generally failed to create a critical mass of well-trained and networked researchers across the continent; increase research productivity; support university-wide systems critical to success and sustainability in research and training in Africa; address issues related to inadequate local training and poor retention of human resources for research, research leadership, and information access; and strengthen the interfaces between research, producers and users.

The African governments have also failed to create '**centers of research excellence**' on the continent and to institutionalize and systematize research work of planners, managers, and policy makers. On the other hand, low-input agro-ecological systems have been proven to deliver safe and abundant food while keeping seeds within the control of farmers and free from patent restraints.

SESSION 1: SCIENCE AND EMERGING TECHNOLOGIES IN AGRICULTURE

The session was chaired by Prof. Rajaa Cherkaouli El Moursli from Morocco. The main speaker for the plenary was Prof. Florence Wambugu, Africa Harvest-Kenya who outlined the use of gene editing technology for 'Sustainable Agriculture in Africa'. Gene editing-alteration of the genetic material of a living organism by inserting, replacing, or deleting a DNA sequence, typically with the aim of improving some characteristics of a crop or farm animal or correcting a genetic disorder.

Farmers have always bred crops and animals to draw out traits that make them more wholesome and sustainable. In addition to improving food quality, gene editing technology can help farmers control pests and diseases and adaptation to changing environmental conditions. This falls within the ambit of biotechnology; the use of biotechnology can enhance production of more food on less land, by reducing the amount of crops lost to disease and pests. The application of biotechnology, including embracing use of genetically modified organisms (GMO) can reduce CO_2 emissions from the farming process, the quantity of pesticides used to produce foods, and in the future, the amount of water needed to grow crops. 'Modern Biotechnology' is helpful in enhancing taste, yield, shell life and nutritive values (bio-fortification) of crops. It was noted from the presentation that gene editing can significantly contribute to agricultural solutions that Africa needs - e.g., in addressing drought tolerance, disease and pest management as well as nutritional enhancement and environmental resilience. However, Africa has limited capacity in Gene Editing Technology (GET) and that capacity needs to be enhanced in all the five regions of Africa.

The Strategies required to Improve GET Acceptance in Africa include:

(i) Enhance capacity, knowledge and numbers of GET scientists;

(ii) Create awareness on potential benefits of GET especially in Africa;

(iii) Foster a facilitative regulatory regime for GET and not treat them as GMOs; and

(iv) Nuclear Science Techniques in Agriculture.

'Enhancing Food Production in Africa through Utilization of Nuclear Techniques' topic was presented by Dr. Yousuf Maudarbocus, Mauritius Academy of Science and Technology (MAST). The role of nuclear energy in agricultural transformation by boosting agricultural productivity was discussed, highlighting the challenges facing Africa and more specifically, that of one in five Africans going hungry with a population of 140 million facing acute food and nutrition insecurity.

Nuclear technology provides an opportunity to enhance food production through the development of disease and drought tolerant crops, soil and water management, plant breeding including GMOs where gamma rays on maize or other plants allow desired plant and animal traits to be selected. Examples were given of the GM crops that were currently approved for adoption in Africa namely: Mutant wheat variety known as 'Njoro BwI' in Kenya that is tolerant to drought and moderately resistant to wheat rust and cassava variety "Tek Bankey " in Ghana that has improved cooking quality.

Reports were given on ongoing projects in African countries on GMOs produced using nuclear science techniques which include: a) Cote D'Ivoire - production of maize, cassava and rice; b) Tunisia: production of drought resistant and heat resistant varieties of barley; (c) Tanzania - production of rice varieties tolerant to salinity; and (d) Mauritius - production of heat tolerant tomatoes. Other beneficial uses of nuclear techniques include control and eradication of tsetse flies, as noted in Zanzibar where the Association of Animal Diseases in 1997 used radiation to sterilize the male tsetse fly; cross breeding of cows that led to increased meat and milk production; eradication of new world screwworm; effective pest control measures; increased soil fertility and production of enhanced stress tolerant crop varieties.

During the panel discussions involving Prof. Mathews M. Dida (Kenya); Prof. Kavwanga Yambayamba (Zambia) and Prof. Habiba Chaabouni (Tunisia), they underscored the following:

(i) The need to invest in scientific research to unravel the key dilemma on GMOs and gene editing technology to provide scientific facts for policy and decision making including empowering farmers with correct knowledge and information;

(ii) There is need for a radical transformation in Africa to recognize agriculture as a science, business and a profession, rather than thinking of the farmers as a peasant; and

(iii)There is the need to raise awareness on emerging technologies such GMOs and nuclear technology not only on the public but also on the policy makers to reduce misinterpretation. People might fear technology due to misinformation and fear of the unknown amongst other reasons. This should be accompanied by introduction of Masters and Bachelors degree programmes in Nuclear Science in the universities; for instance as is the case in Morocco.

The following were identified as the shortcomings of emerging technologies in agriculture to address food security and nutrition challenges:

(i) Lack of awareness and misinformation on technology that started from Europe comparing Gene Editing Technology (GET) to Genetically Modified Organisms;

(ii) Limited resource capacity (human and facilities) in view of enormous challenges in Africa especially in the use of emerging technologies such as artificial intelligence, drones and nuclear technologies just to mention a few;

(iii) Restrictive policy and regulatory frameworks which started in South Africa and EU; and - limited commercialization of technologies and research products in Africa;

(iv) There is a need to incentivize young people to accommodate agriculture and new technologies to boost food production; and incentivize the youth to actively participate in agriculture by maximizing their strengths on use of modern information communication technology tools; and

(v) Updating, upgrading and/or establishment of national gene banks to preserve the plant and animal germplasms is crucial.

Artificial Intelligence

This is yet another innovative emerging technology in food security and food systems. Artificial Intelligence (AI) stands out as one of the emerging technologies with great potential to transform the sector and provide sustainable solutions to food security in Africa. Artificial intelligence and machine learning can be used to identify researchers and institutions with strength in a specific research area. The data obtained can be ranked through big data analytics hence the visibility of African researchers. This ranking can also be done through online page ranks such as 'Google' page ranks.

Artificial intelligence in agriculture has the following potential applications:

(i) ***Prediction of crop yields*** tools to help farmers make ideal decisions in crop yield forecasting and improve smart farming practices that lead to higher yields;

(ii) ***Prediction of soil management properties*** tools for understanding soil conditions and how to boost its performance to support productivity;

(iii) ***Farm management systems*** tools for precision agriculture to detect and perform farm management operations such as planting, irrigation, pollination, weeding, fertilizer application, harvesting, etc.;

(iv) ***Pest and disease detection*** early detection of pests and diseases in the farm and eventual prevention or control;

(v) ***Smart mechanization*** tools to reduce drudgery in agriculture and minimize inputs, high autonomous and intelligent machines and agri-robots;

(vi) ***Livestock surveillance*** for monitoring illnesses, injuries, and even pregnancies;

(vii) ***Food demand monitoring*** tools for real-time monitoring and control of changes in food demand;

(viii) ***Supply chain management*** tools for monitoring food origin, quality, and safety that affords transparency, trust, certification, and traceability of food product supply chain from farm to fork;

(ix) ***Food retailing*** tools for predicting consumer demands, perceptions, and buying behaviour;

(x) ***Transportation and storage*** preservation of food product quality, to ensure safe food products and to minimize the product damage; and

(xi) ***Inventory management*** prediction of daily food demand and to ensure that there are no inventory-related problems.

Unmanned Aerial Vehicles (UAVs)

Unmanned Aerial Vehicles (UAVs like drones) play an important role in collecting high resolution data which makes them a valuable asset. When a drone flies over a farm with the sensing technology needed to collect data; the data can be analyzed and used in practice. UAVs can be used in the spraying/broadcasting and applications of pesticides/fertilizers in the field. Since drones are more flexible to operate and manipulate over time and space, farmers have a better opportunity to get quick and specific overviews of field situations in real time.

SESSION II: CLIMATE CHANGE, ENVIRONMENT AND AGRICULTURE

The session was chaired by Ms. Jackie Kado, Executive Director NASAC. The main speaker was Dr. Deoraj Caussy, Mauritius and other presenters were Dr. Jesse Owino, Kenya Forestry Research Institute; Ms. Anne Gudere, KALRO and Dr. Philip Osano, Center Director for Africa, Stockholm Environment Institute (SEI). The presentations were followed by a discussion panel and the discussants were Prof. Josephine Ngaira, Kenya; Prof. Bi Guime Crepin, Cote D'Ivoire; and Prof. Charles Nhachi, Zimbabwe.

The session brought forth information on the impact of climate change and environment on agricultural productivity and food systems in Africa. It comprised of three presentations whose key messages were as follows:

(i) Policy makers need data in order to make and implement sound policies and climate change requires global solutions beyond the capacity of most African countries. Therefore, there is a need to train critical mass of expertise, build additional partnerships for resources to strengthen knowledge, skills, and technological transfer.

(ii) Strengthening science policy interface through capacity building, research, exchange programmes, collaborations and integration of indigenous knowledge. The presentation on 'Protecting Human Health from Climate Change in Africa' highlighted the impacts of climate change on ecosystems, evidenced through the melting ice in Mt. Kilimanjaro, change of river course affecting small scale farmers in Africa, multiple climate sensitive vector borne diseases such as malaria, foot and mouth leading to high livestock mortalities. It was reported that one climate hazard can escalate too many related hazards in the various sectors. For example, agricultural pests such as locusts contribute to food scarcity and water contamination but public health is missing in the adaptation policy. Coupled with this is the issue of insufficient research evidence to inform policy.

'Achieving Food Security under Climate Change' also requires Forestry and Land Restoration. It was observed that the cause of land degradation in the arid and semi-arid lands is often also accompanied by the occurrence of invasive plant species.

Potential opportunities for habitat restoration and land use management were identified as: grass seed banks; planting species that are sustainable for the water catchment areas e.g., gums and resins; and community engagement. A survey on Agro-Pastoralists Determinants of Crop-Livestock Smart Technologies to Climate Change (e.g. in Marsabit County, Kenya) revealed that there is need to have researchers come on board and look for ways on how the manure from the

ASALs can be packaged and sold to relevant people that might need it. This will also help the pastoralists diversify their sources of income.

Climate change affects food security in all its dimensions: access, availability, utilization and stability. The net impacts of climate change on food security and nutrition depend on the magnitude of the climate change effects themselves, and on the underlying vulnerabilities of food systems. At each stage of the "**cascade of impacts**", vulnerabilities exacerbate net impacts. In addition, vulnerability can increase over time if systems/households face repeated shocks that steadily erode their asset base and capacity to respond.

The populations at greatest risk are those that are dependent on agriculture and natural resources, with livelihoods that are highly exposed to climate change impacts, and who have very limited capacity to respond. Indigenous peoples, who depend on the environment and its biodiversity for their food security and nutrition, are at high risk–especially those living in areas where significant impacts are expected such as the Arctic, mountain areas, the Pacific islands, coastal and other low-lying areas. Fishers, fish farmers, post-harvest workers and their dependent communities and infrastructure are particularly exposed. In some cases, to cope with risks and changes, the only option can be to migrate, nationally or internationally, with a range of implications.

Climate change threatens to reverse the progress made so far in the fight against hunger and malnutrition. As highlighted by the latest assessment report of the 'Intergovernmental Panel on Climate Change' (IPCC), climate change augments and intensifies risks to food security for the most vulnerable countries and populations. Four out of the eight key risks induced by climate change identified by IPCC- AR5 have direct consequences for food security:

(i) Loss of rural livelihoods and income;

(ii) Loss of marine and coastal ecosystems, and livelihoods;

(iii) Loss of terrestrial and inland water ecosystems, and livelihoods; and

(iv) Food insecurity and breakdown of food systems.

At global level, climatic shocks impacting areas of global importance for food supplies can have remote impacts through effects on:

(i) Supply flows and food price spikes, with increased market volatility; and

(ii) Impacts on bilateral contracts and/or import/export behavior, with disruption of trade patterns.

The possible solutions to climate change are the following:

(a) **Building resilience of agricultural systems:** Agricultural systems can be made more resilient, by implementing measures that are very system-and local-specific. Individual farmers, forest dwellers, fisher-folk and those along the supply chain will need to adopt a suite of measures, the details of which will be contingent on individual circumstances. For example, increasing the efficiency of scarce resource use in productive systems, particularly water is an important aspect of building resilient livelihoods. Climate change is altering rainfall and water availability patterns, making capacity to deal with water scarcity (or overabundance) essential to maintaining productivity levels.

Adaptation measures can include water harvesting and storage, access to irrigation, improved irrigation technologies, as well as agronomic practices that enhance soil water retention such as minimum tillage, and increase in soil carbon and organic matter, among others. Adaptation measures for crops can include the use of adapted varieties or breeds, with different environmental optima and/or broader environmental tolerances, including currently neglected (orphan) crops, also considering that increased diversification of varieties or crops is a way to hedge against risk of individual crop failure.

(b) **Fishing, fish-farming practices and management** will need to adapt to changing species composition and location and increased risks at sea. Changes in the distribution of fish will require adapting fishing effort, with flexible allocation and access schemes. Adaptation options to declining or variable yields in terms of fisheries technologies and management will need to be carefully assessed, to avoid exacerbating the overexploitation of fisheries or impacting habitats.

For aquaculture, a set of adaptive practices has been identified, such as diversified and integrated aquaculture systems, water quality monitoring, species selection, selective breeding, genetic improvement, site selection, and improved cage and pond construction. Increasing the diversity within production systems will help spread risks. This can take many forms viz.: combining different types of production (crop, forest, fish and livestock) in different ways; increasing the numbers of different species, populations, varieties or breeds; increasing the use of materials that are themselves genetically diverse such as crop multiline. Adaptation action can be conducted at landscape level; for instance watershed protection and management, fire management, erosion control, coastal zone management, and pest and disease control.

Adopting a landscape approach to management includes taking into consideration the physical and biological features of an area as well as the institutions and people who influence it. Landscape-level adaptation will require appropriate institutions and policies to improve coping capacities of communities.

(c) **Securing land tenure** is paramount to enable farmers to benefit from the value added on the land and to encourage them in adopting a long-term perspective. The voluntary guidelines on the responsible governance of tenure of land, fisheries and forests in the context of national food security adopted in 2012 by the Committee on World Food Security promote secure tenure rights and equitable access to land, fisheries and forests.

(d) **Collective management of natural resources,** including land and water, is particularly important for adaptation, especially at landscape level. Policies and institutions need to account for the specificities and needs of pastoral systems and indigenous peoples in terms of management of natural resources, and their particular needs in terms of adaptation to climate change. Improving land use and management, or changing farming systems can bring long-term adaptation benefits but often imply significant up-front costs either in inputs or labor, and/or reduced income during the transition period.

Some of the questions that were interrogated included the following:

Can African Agriculture thrive in warmer and wetter areas? or "How does one enhance resilience of farming systems and social safety nets in Africa?"

Some of the interventions proposed were as follows:

(i) Integrated action on air pollution and climate pollutants has a strong impact on crop production e.g., rice, maize and wheat. Green economy may not be achieved due to environmental pollution;

(ii) Cross border cascading climate risk - the impacts of climate risk is now more complex as it is a compounding risk and hence is difficult to manage. Climate hazards impacting one part of the world impact the other;

(iii) Continental or national adaptation strategy- e.g., there is a challenge on fertilizer used in crop production that ends up polluting the ecosystems; and

(iv) Environmental agreements signed by African countries must be accompanied with accountability frameworks.

SESSION III: SCIENCE DIPLOMACY, COMMUNICATION, POLICY ANALYSIS ON AGRICULTURE AND FOOD SECURITY

The session was chaired by Prof. Norbert Hounkonnou, President of NASAC. The main speaker in the session was Dr. Margaret Karembu (International Service for Acquisition of Agri-Biotech Applications- ISAAA AfriCenter); the presentation was given by Ms. Bibiana Iraki. The other presenters were Prof. Philani Moyo (University Fort Hare, South Africa) and Prof. Dorington Ogoyi (Technical University of Kenya). The discussants for the session were Prof. Ishmael Masesane (Botswana), Prof. Omar Sock (Côte D'Ivoire) and Prof. David Miano (Kenya).

ISAAA-AfriCenter gave a presentation on Science Communication: A Key Enabler of Sustainable Agriculture and Effective Food Systems in Africa. They vouched for science communication as key towards acceptance of agricultural technologies and innovations in Africa. Effective science communication strengthens the connection between science and society, thus building the much needed confidence towards scientific innovations in agriculture. One of the approaches emphasized was the importance of scientific communication in promoting sustainable agriculture in Africa using the 'One Health' approach that comprises communication, coordination and collaboration. However, it was observed that one of the problems identified in science communication is the scientists' assumption that their audience will always understand their messages. This is an illusion. Other challenges are: diverse cultures; and varied needs, mixed opinions and clustered socio-economic, strata and education.

The gaps in communication include: silo mentality (insulation); people wanting to know that you care before they care about what you have; and the fact that non-scientists are only interested in the bottom line and not technical details.

In order to ensure that effective communication is accomplished, the following basic requirements are necessary:

(i) Adoption of modern technologies and innovation, which the researchers give meaning to their work in the eyes of the stakeholders, policy makers and taxpayers;

(ii) Support for research that informs policy and practice;

(iii) Sharing of information to enhance communication;

(iv) Increasing engagement across sectors to address conflicts including appropriate platforms; and

(v) Simplifying scientific jargon to make it palatable to non-scientific audiences.

Key messages in scientific communication are:

(i) That the context of the message to be delivered should be simple;

(ii) Developing responsive messages that align with the audience values;

(iii) Simplifying language and jointly developing a glossary of terminologies;

(iv) Walking with the media and policy makers and extension workers right from the onset;

(v) Determining the best time to engage farmers (manage their expectations); and

(vi) Being proactive rather than reactive to build trust. "If the audience trusts you, you do not need science."

A case study on 'Climate Change, Politics and Economics Intersection in Zimbabwe Food Insecurity Crisis of 2019-2020' was presented by Prof. Philani Moyo of South Africa. Policy reflections were given on the following:

a) Production based entitlement.

b) Climate change.

c) Exchange entitlement.

d) Inheritance and transfer entitlement.

It was observed that Zimbabwe's food crisis was as a result of a complex combination of political, economic, climatic and agrarian structure factors.

A presentation by Prof. Dorington Ogoyi, former CEO of National Biosafety Authority on Regulation of Biotechnology and Emerging Technologies for Improved Agricultural Productivity in Kenya: A Case Study of Genetically Modified (GM) Crops. The GMO concerns were demystified and an outline given on the biosafety regulations that should be adhered to ensure that potential adverse effects of genetically modified organisms are addressed so as to protect human health and the environment when conducting environmental release-avoiding GM products for use by the public. It was noted that Kenya signed the **Cartagena Protocol** in 2000, ratified it in 2003 and developed the National Biotechnology Development Policy in 2006. The role of the Authority is to:

1. Facilitate responsive research;

2. Ensure safety of human and health and provide adequate protection on the environment from harmful effects that may result from GMOs; and

3. Establish a transparent science based predictable prospects of GMO.

There is however a gap in systematic engagement between the regulator and public. It was reported that the GMO in the Kenyan market is Bt-Cotton, the application was made in 2015 and the acceptance to release was given in 2019, and farmers started planting Bt-Cotton in January 2020 and are currently in either season 2 or 3.

The second GM crop is Bt Maize that is resistant to stem borer, which has gone through the seed trials but its release was delayed due to the ban on GMOs in Kenya. However, the ban was lifted in September 2022 and Bt maize seed is now available in the market for farmers to plant. 'Virus Resistant Cassava', has moved to the on farm field trials and is available for on-farm performance trials. ***Unfortunately, the introduction of these technologies in Kenya has been put on hold by the courts awaiting litigation.***

During the panel discussions involving Prof. Ishmael Masesane (Botswana) and Prof. Douglas Miano (Kenya), the delegates explored further on the challenges of GM technology uptake in the African continent. The leveraging of science advice to inform policy was delved into as well as issues on science diplomacy; managing science through international relations to strengthen communities relationships; communication as a challenge in science diplomacy; challenges in translating science to inform policy and practice.; interactions/engagements between scientists, practitioners and policy makers to enhance communication.

It was noted that:

(a) Science is central in providing solutions to the problems facing the Agriculture value chains in Africa. Policy makers lack trust in scientists but always consult politicians who are always out to please the masses that vote for them and hence give advice that is not backed by evidence;

(b) To communicate effectively with policy makers, scientists should establish strong relationships with policy makers and practitioners (farmers and consumers) to minimize political interference. Science communication needs to distinguish the integrity of technology, politics and social issues; (c) There is a lack of implementation of science advice from scientists as politicians often have to make decisions on a daily basis while science evidence takes a long to produce; Scientists share good information but do not communicate effectively, thus there is a need to package information in forms that are understandable to the real end users of the information; and mark out the politicians that

can champion policy reforms and embrace them. i.e., identify scientists in parliament and use them as science champions and use them as entry points or agents of change or influencers to help draw a strategy on communication with the politicians.

A new era of the global world class ushered in a new philosophy of one village where nations are intrinsically linked in their shared prosperity and adversity. The MGs and SDGs have specific targets for the countries to adhere to. Challenges such as climate change, food and nutrition security, poverty reduction, biodiversity loss and pandemics are global and therefore require concerted efforts from the global community in tackling them.

Although efforts are continually being made by the international community in tackling these challenges, the desired results are yet to be achieved. The practice of science diplomacy aims at bridging science and policy in international spheres in favor of national, inter-state or global interest. It seeks to promote scientific collaboration through international partnerships, inform foreign policy objectives and facilitate international cooperation and investments. Science communication is vital for the communities to appreciate the demand for correct messages. Important research which is accomplished by scientists does not get utilized because of poor absorption of the results. Demystification of science communication cannot be emphasized enough within the African countries.

SESSION IV: CAPACITY BUILDING, SCIENCE TECHNOLOGY AND INNOVATION (STI) AND COMMUNICATION FOR SUSTAINABLE AGRICULTURE AND FOOD SYSTEMS IN AFRICA

The session was chaired by Ms. Bibiana Iraki of ISAAA AfriCenter. The main speaker was Dr. Immanuel Okogbenin of African Agricultural Technology Foundation (AATF). Other speakers were Godwin Lemgo (Bayer CropScience Africa), and Dr. Albert Washington Ochung Tambo (Maseno University, Kenya). The discussants for this session were Dr. Susan Musembi (Kenyatta University); Dr. Silas Obukotsia (AUDA-NEPAD, Kenya) and Joshua Takalimane (Lesotho).

The main speaker outlined the role of Agri-Innovation in building sustainable Agriculture, noting that agriculture provides food, fiber, fuel and industrial raw materials. He pointed out that there is need to:

- Employ innovative technologies to help the farmers maximize yields;
- Deploy locally developed varieties of food crops (maize) to different parts of Africa using a multi pronged product pipeline through conventional plant breeding and transgenics; and
- Mechanize farming through use of drones to collect, validate and analyze data.

The take home message from the presentation was that innovation is a critical catalyst for sustainable transformation.

Godwin Lemgo in his presentation on 'Moving from Research to Commercialization: A Case of Biotech Crops', pointed out that there is a need for collaborative action by all stakeholders - public, private sector and academia. The key enablers in this endeavor were identified to be:

a) Involving political leadership.

b) Technology acceptance.

c) Evidence based policy framework.

d) Protection of intellectual property.

On his part, Dr. Albert Washington Ochung Tambo, who presented on the 'Role of Supply Chain Management in Building a Sustainable Competitive Agribusiness in Developing Economies',

observed that: in the food industry, the efficiency of the supply chain is vital to profitability and safety. When one link in the food supply chain, such as a farmer or packaging plant, is not operating at peak performance, every other link in the chain is negatively affected. There are many opportunities within the food supply chain to increase efficiency, safety, and productivity. By harnessing the power of the latest trends, you can ensure your supply chain is managed effectively, contributes to your profitability, and provides a safe and high-quality product to consumers.

Collecting robust data on a product as it moves through the supply chain is crucial to adequately managing processes. Without technology, collecting this data is time-consuming and there is extensive room for error. Advancements in technology allow professionals in the food industry to automate these processes so that they are more efficient and precise. Examples of some of these technologies are automated inventory systems, GPS systems, and predictive analytics. These new technologies are still only minimally used in Africa. It was noted that:

(i) Supply chain industry must be managed to ensure measures are taken to avoid foodborne contamination as well as ensure a steady food supply to those who need it most. This is particularly important during pandemics like the COVID-19;

(ii) Some national food banks rely heavily on charitable contributions of both companies and individuals. This scenario is unsustainable as a means of finding a permanent solution to food insecurity; and

(iii) Food insecurities can emerge at different points along the supply chain and we have to be ready to respond at each stage. At the point of production, the insecurity is created because the food doesn't stop growing. If the farmer can't get it delivered to the market because packaging sizes and expensive transportation resources make it too costly, the food goes to waste. Even if the food does make it to retail outlets, often customers can't or won't pay the higher prices (driven up by the higher transportation costs), then it will sit idle on the shelves. This results in the baffling combination of simultaneous excessive food waste and lack.

Pandemics like COVID-19 can cause panic purchasing. At the point of consumption, the problem can be further exacerbated by the fact that grocers didn't realize people would converge on their stores to buy a month's worth of food. Months later, store shelves were still empty and thus aggravating food insecurity.

During the panel discussions, it was outlined that:

Innovation centers to support young entrepreneurs in Africa are limited. Frameworks on business startups and commercialization have never been taken seriously in knowledge generating institutions. The return on investment is quite silent in our institutions as in the majority of cases there are very few 'Intellectual Property rights' offices and when they exist, the challenge is that of understaffing. Do we have teams that can exploit the patent? This calls for the need for technology transfer questions from the research laboratories to the industry so that commercialization can take place. This calls into question whether patent management is well developed at all in Africa. Currently, most African countries have linear innovation systems but there is need to establish national innovation systems as enabling support systems to knowledge producers to help strengthen innovations and commercialization initiatives. Although the requisite policies are often in place, implementation is never executed effectively. Africa currently has a huge youth population which could drive innovation but support systems are the issue. Innovations must be done in an innovation hub and prototypes developed, and here public-private-partnerships would be the way to go with very strong government backing. Science Academies play an important role in helping governments develop pathways into robust innovation systems that support commercialization. In this respect, it is worth noting that SADC member states agreed that every country should have a 'Science Academy' to support institutional leadership, develop R&D and develop an entrepreneurial mindset.

The key questions that need to be addressed include:

1. How do we capacity build the farmers?
2. How do we come up with a new breed of farmers who are largely informed as to change their perspective on farming?
3. How do we empower farmers so they can be more impactful in agriculture?
4. What is the role of Science academies to impact politicians and move from basic research to application?

Capacity building and scientific communication is central to guarantee that agriculture performs along the value chain and ultimately has a positive impact on livelihoods. The progress in ensuring a sustainable and equitable food supply chain will be determined by how coherently the persistent challenges are tackled and solutions communicated to the beneficiaries. In recent years, a renewed focus on agriculture has been evident in the policy and development agendas across the African continent. Yet, little knowledge has been generated on the inter-linkages of research and development, agricultural production, and markets, as well as the potential for

developing them. Despite the establishment of many agricultural training colleges and Faculties of Agriculture in many African universities, there is still a big disconnect between capacity building and agricultural productivity in the continent.

SESSION V: RESEARCH CAPACITIES OF AFRICA'S UNIVERSITIES AND RESEARCH INSTITUTES

The session was chaired by Dr. Evelyn Gitau-Interim Director of Research, APHRC. In her opening remarks she pointed out the importance of creating a good environment to decolonize research in Africa through building partnerships. The important question is how to create geographical equity in research by engaging the governments in the continent.

The main speaker in the plenary was Dr. Catherine Kyobutungi, Executive Director, APHRC who gave a very encouraging speech on the role of universities and research institutions. She stressed the need to collaborate and utilize the available resources to better the lives of its citizens. The other presenters were Dr. Julius Kirimi Sindi and Dr. JPR Ochieng'-Odero. The discussants in the plenary were Prof. Abdess Salem Saumtally, Mauritius, Ms. Charity Musembi, NACOSTI, Kenya and Ms. Jackie Kado, Executive Director NASAC. The session was assured of APHRC's support in the future research needs.

The key highlights:

Africa needs to embrace and scale up implementation of research (IR) as an integral step to link research and practice to accelerate the development and delivery of public goods and services. Implementation of research involves the creation and application of knowledge. Adoption of IR will ensure that research outputs are relevant to policy making. Africa faces the most pressing human development needs and requires an increase in the number of women involved in implementation of research outputs. African universities and research institutes have the capacity to test and adopt evidence based innovations generated from agriculture, health, and economics. This will result in a strengthened ecosystem for implementation research in Africa anchored on a network of highly capacitated academic and research institutions on the continent. It is important that African scientists need to be visible on international platforms to compete with other more developed universities and research institutions.

The voice for African Science Academies should help policy makers put science, technology and innovation at the forefront of national and continental development. The outcome of the evidence based research will boost Africa's capacity to sustainably meet the food and nutrition security for the growing population and enable the continent to trade better internally and regionally.

The need and opportunity to improve agricultural productivity will require synergy with other related investments particularly setting an enabling policy environment, capacity building and communication. The national science academies, universities and research institutions in the continent will endeavor to promote technology-led investments in sustainable agriculture by

strengthening integrated skills development and entrepreneurial capacity to stimulate commercial financing in agriculture.

To successfully achieve sustainable agriculture in the continent the science academies, universities and research institutions in Africa will be encouraged to promote agricultural productivity to improve the livelihoods of the farming communities and improve their food and nutrition security. This will require a transformative change on how the research outputs are shared, delivered and communicated.

Dr. Catherine Kyobutungi also delved into the issue of the current research capacities of African universities and research institutes; with a focus towards a stronger research ecosystem in Africa. First, she gave an overview of APHRC and its operation in the 35 countries of Sub-Saharan Africa with a global health lens. She emphasized that it was important to understand how the African research institutions and universities use research as a tool to contribute to transformation of lives in the continent.

Dr. Kyobotungi went further to elaborate on how research can transform life through application of research in decisions that directly or indirectly impact lives. She outlined the 'theory of change' for APHRC that research can transform lives when done and robust scientific inquiry is evidence based. Hence research should be done by more and more people so that the evidence emanating from the findings is widely applied by more and more people. Research has been very instrumental in supporting policy, program and project design, implementation and improvement; service delivery, development of guidelines for practice, uptake of tools and innovations, and budget allocation. Unfortunately, decision makers don't use research findings when making decisions but just as an advisory tool.

Further, Dr. Kyobutungi elaborated on APHRC's work based on 'Evidence Informed Decision Making (EIDM) Framework' that takes into consideration the context, Africa's researchers' contribution to the science of Covid-19, gender inequality, black lives matter and decolonization of the global health movement. This has resulted in the shift of the discussions on the way global health initiatives take place. Also, the analysis of donor funding distribution across the world has shown that the biggest chunk of these funding are received by developed countries while African countries receive the least. For example, funding for Africa from the Bill and Melinda Gates Foundation (BMGF) has mainly gone to developed countries such as the US with US institutions receiving 50% of the funds whereas African countries such as Kenya 9% and Nigeria 7%.

On the global front 90% of the health research grants were in the other countries while Africa received 10% of the grants with majority of the recipients' being Northern Africa countries such as Morocco, Algeria, Egypt, and Libya. Therefore, with the limited ability of Africa to access the donor funds, the key question is; '*Is Africa ready for transformation?*'

Today there is a shift recommending the engagement of African organizations in implementing health initiatives because they understand the environment better. Therefore there is increased willingness by donors and development partners to shift to direct grantees in Africa. Dr. Kyobutungi posed a number of questions to the delegates: "Is Africa ready for this shift? Where are the African research institutions and scientists who are ready? What is the added value of current research activities in Africa?" Hence there is a need to increase investments in building the capacity of Africa's institutions.

Africa being the home of 15% of the global population contributes only two percent (2%) of global research and one percent (1%) of the funding. Dr. Kyobutungi reiterated that one of the contributing factors to limited access to global funds by Africa is the limited number of researchers in the continent to strengthen the research policy dialogue. It is estimated that the continent requires at least one (1) million more scientists annually in order to spearhead the African research agenda and develop the capacity to implement research. She outlined the challenges facing the scientists in Africa.

Challenges of Finding African Scientists:

Research grant applications are mostly by invitations. This requires networks and personal relationships which takes time. This mechanism further minimizes the potential pool of grantees:

- Program Officers rely on trusted networks; this means that they are only able to access a small pool from the global north who their friends and colleagues work with regularly;
- Program Officers prefer regional hubs, or grantees that have capacity to implement regional projects; and
- Development partners also prefer institutions they have worked with and delivered on their projects.

The funding agencies can identify potential African scientists during conferences but only a few attend such conferences. Also grant funders can find potential grantees through references. The African scientists are not visible and do not respond quickly to enquiries and many of them are not searchable through Google Scholar.

The characteristics of African institutions in the research ecosystem are as follows:

(a) Grant applications are mostly done by institutions;

(b) Low response rate from African universities due lack of awareness and sensitization: Many university websites are not updated and contains stale information;

(c) Lack of visibility for African research in journals, conferences and repositories;

(d) Low capacity to generate primary funding and access national funding;

(e) African institutions lack regional presence;

(f) Capacity building left to researchers alone; and

(g) Disconnect between scientists and industry. The need for collaborations and partnerships: a call for action for Africa scientists, institutions and academies.

Dr. Kyobutungi presented the approach APHRC was using to leverage the existing networks for research capacity building with the experience gained from the Consortium of Advanced Research Training in Africa (CARTA) program.

The area of focus in this program is building a cadre of researchers in Africa via selected universities doctorate and postdoctoral training. The program has the first cohort of 235 PhDs and 230 fellows with a deliberate initiative to retain women in the program.

The Consortium for Advanced Research Training in Africa (CARTA):

CARTA is a consortium of eight African-partner universities, four research institutions, and nine Non-African partner institutions jointly led by the African Population and Health Research Center (APHRC), Kenya, and the University of the Witwatersrand (Wits), South Africa.

CARTA areas of focus:

- Building cadre of university institutions achieving PhDs;
- Initiatives that strengthen the R&D ecosystem in Africa;
- Mainstreaming innovation into education systems;
- Developing Models and prototypes;
- Funding management and technical thinking partner;
- Addressing the disconnect between funders and academia; and
- Increasing inclusion and participation.

Dr. Kyobutungi concluded her presentation by posing a number of questions that formed the basis for discussions during the plenary discussions. These questions will form part of the fact-finding missions to link up the African scientists in the continent.

- Where are the African scientists?
- Where are African research institutions?
- Is Africa ready for the shifts in thinking for future research funding?
- What are the pitfalls of such funding shifts?
- How long will this shift last?

In her concluding remarks Dr. Kyobutungi highlighted the experiences gained from the institutions in the continent on research funding. The African institutions must differentiate themselves with the rest of the world on what they are good at. This has been demonstrated by institutions like Makerere University in Uganda with a well operated innovation hub and capable of managing large grants. Therefore, universities and research institutes in Africa can build partnerships and learn from one another.

In summary, Dr. Kyobutungi posed several questions which would form part of the discussion:

1. There are African scientists but do we know them?
2. Good research is going on in Africa but who knows where it is taking place?
3. Recognize there are many stakeholders in the research ecosystem, hence we must deliberately work towards building partnerships;
4. What is the verifiable way to find research experts? Where is the information?
5. Need to build the capacity to decolonize research agenda; and
6. Deliberately make African scientists visible.

With the deliberate move by donors and development partners to increase direct funding of African institutions from 10 percent (10%) to 25 percent (25%) is this achievable with the present research ecosystem institutional capacity in Africa? Therefore, there is a need for continued engagement with researchers and institutions in Africa to discuss future research initiatives to be undertaken.

The presentation by Dr. Kyobutungi was followed by two technical presentations by the Program Managers from the African Population and Health Research Center (APHRC) on the ongoing programs in the institution.

The session on the '**Gates Catalyze Impact Projec**t' was presented by Dr Julius Kirimi Sindi. He highlighted the challenges faced by African scientists and concurred with Dr. Kyobutungi on poor response to enquiries by African scientists and institutions. This contributes to the failure of the institutions to attract funding. The thinking of APHRC is to catalyze the change in the research ecosystem and culture of the researchers. Africa cannot create jobs without increased research innovations and patents. Therefore, there is an urgent need to change the African research ecosystem to enable academicians, researchers, entrepreneurs, and industry to work together to promote commercialization of research outputs.

He then presented the activities of the ongoing Bill and Melinda Gates Foundation (BMGF) supported project at APHRC. Gates Foundation is targeting spending US$ 7 billion annually in Africa. Some of these funds will go into research funding through universities and research institutes in Africa and promotion of transformative approaches to research. The project focuses on the transformative approaches to research in Africa and will address the following:

- Working together of African researchers to re-engineer the research platform;
- Increase African institutions which conduct good research;
- Provide profiles of research institutions and researchers;
- Establish a research matching platform;
- Increase the number of universities and research institutions that receive grants from the Foundation;
- Increase in the number of African universities with capacity in terms of resources, physical infrastructure;
- Improving the ways researchers deal with culture;
- Promote innovation to create industries;
- Provide data depository and establish a framework for public data sharing; and
- Create a system of linking researchers and government agencies.

Dr. Sindi further outlined the approaches to engage with science academies and indicated some of the activities APHRC would envisage to undertake with academies of science in Africa.

Proposed activities that APHRC would pursue with the academies of science:

- Sensitizing universities/research institutions about the opportunities provided by the project;
- Improve academies of science and institutions web-based visibility;
- Participating actively in providing data including needs assessment on capacity;
- Ensure the academy journals are indexed by international indexers; and
- Developing supporting programs for early career researchers and participation of women.

The above outlined activities will provide the opportunity for the African academies to engage with APHRC on the various programs being implemented by the institution. This will also give Africa Science Academies the opportunity to make a transformative change on how the research outputs are shared, delivered and communicated.

Capacity Gaps in African Universities and Research Institutions:

Dr. JPR Ochieng'-Odero presented the process of institutional research partnerships as a way to improve the performance of African universities and research institutes in dealing with capacity gaps. He outlined the game changing outcomes for greater visibility of research in Africa and how to strengthen the research ecosystem for increased research impact. He outlined the importance of building capacities for the countries and institutions in order to respond to the changing global research and development ecosystem. For instance, the national science academies are uniquely placed to provide change and advisory to the national policies. The academies provide linkages of academies with academia and research institutions.

The presenter outlined further game changing outcomes for greater visibility of the national academies which include:

- National science academies are influential advisors to government;
- Academies have an integral link with academia, universities and research institutions;
- Academies have a unique role and ability to network regionally;
- Academies are well recognized by development partners;
- Academies are important sources of knowledge for policy formulation;
- Sensitization of universities and research institutes in the countries;

- Improvement of academies web-based visibility; and
- Capacity improvement of research management processes.

The presentation also focused on improving visibility of African researchers on international platforms. A scoping review undertaken earlier showed that African journals lack visibility on international platforms; Google scholar, Scopus, Web of Science, International Standard Serial Numbers (ISSN) portal, Directory of Open Access journals and publishers being members of Committee on Publications Ethics (COPE). This clearly indicates that finding African researchers through their work published online is very difficult. The few journals indexed and visible on international standards had a low h-index, which informs their low visibility online.

The Panel discussions outlined the following:

- Even though there are enormous possibilities for Africa, the continent has not been able to take advantage of these openings due to limited regular updates of the websites (Information that is outdated);
- National research institutions are not taking advantage of the available research funding;
- Research should be demand driven, relevant , and beneficial to the farmers in the context of food security;
- Africa lacks innovations and generates very few patents;
- Need to develop partnerships among institutions as the research may be too much for one institution to encourage interdisciplinary collaborations;
- The African science academies have 28 NASAC academies and APHRC can leverage on the exciting pool of experts in the national academies and use these academies as entry points for research;
- The Government of Kenya through NACOSTI has already made proposals to have research funding in Kenya increase from 0.8% to 2% of the Gross Domestic Product (GDP). The NACOSTI mandate of mainstreaming science, technology and innovation in the country NACOSTI is responsible for mainstreaming of STI in the country; 400 institutions conduct research but only 196 report on innovation;
- Researchers should provide assurance why the government should commit research funds;
- Limited data is available on the innovation index;

- It is important to use both internal institutional channels and external channels by approaching existing networks and work relationships for recommendations on the most suitable candidates. The researcher must meet the criteria of being beneficial for the purposes of the project while maintaining the funder's guidelines. For instance Ms. Kado an illustration on how the "Gene Editing Technology in Africa" project was conceptualized with the potential funding agency questioning NASAC of possibility of finding African institutions doing gene editing research in the continent;

- **Grant Writing Skills:** Every project requires a communication expert separate from the researcher, whose focus should be on the research, to translate the research into something that a non-scientist can comprehend. A financial person is also required to work on a solid project proposal and in the financial reporting of the project; and

- **Know the Relevance of the Research:** This will ensure that research results are appropriate and timely and also increase the uptake of the project deliverables. There is a need for community engagement in order to validate the research results.

Some of the questions that were raised during the panel discussion include:

How can APHRC engage the science academies?

- The data on African researchers is available in the respective science academies.

- Inaccessibility of African researchers and recognition of local researchers by the funding partners. In many cases African researchers are found at the bottom of the list of authors in the publications emanating from the work done in the respective countries. There is a need for democratization of the research findings where the researchers are given equal treatment.

- The need for African scientists /researchers to follow the guidelines provided by the funders in order to qualify for the research funding. There also exists competition between the different donors and the attitude of the donors. There is an urgent need to have proactive African researchers so as to attract funding.

On the issue of grant making and timely response to grant calls there is a need for African researchers to acclimatize themselves on the requirements of grant making and APHRC could provide training for the researchers on the process of grant making and management.

GENERAL RECOMMENDATIONS FROM THE CONFERENCE

(i) There is the notion that new technology e.g. GMOs, gene editing, nuclear science techniques among others are a panacea to the food insecurity and malnutrition in Africa. However, there is no evidence to support this claim. Africa's current production systems have not achieved the full potential of existing technologies. Hence, we recommend promotion and adoption of the proven existing technologies to address food and nutrition challenges in Africa.

(ii) Importation of food into the continent is not a solution to food insecurity. To this end, it is vital for African states to empower research institutions to find locally tailored solutions to address local food and nutrition challenges.

(iii) The recommended 2% of the GDP to research recommended by the AU, signed and ratified by African states should be implemented.

(iv) The African Governments should enhance and strengthen proper frameworks for data protection and management; development of data sharing protocols to allow institutions to share and access data as public goods.

(v) The mandates of 'National Science Academies' in Africa should be enhanced to provide evidence based science advice to policy formulation.

(vi) Science diplomacy should be leveraged in solving trans-boundary problems which could otherwise threaten neighboring countries' food systems, peace and environment.

(vii) Research outputs should be translated into languages understandable to stakeholders and use appropriate mediums of communication accessible to stakeholders by engaging media houses.

(viii) Researchers and research institutions should work on their visibility on international platforms to increase their chances of receiving research grants.

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APPENDICES

Appendix 1: The Annual Meeting of African Science Academies (AMASA) 2022

Press release 1

The three (3) day 'Annual Meeting of African Science Academies (AMASA)' is taking place in Nairobi from November 28th -30th 2022. The Nairobi meeting has brought together the representatives from 23 African Science Academies, Governments, private sectors, development organizations, research institutions, etc., from the continent to discuss the latest ideas and appropriate solutions and technologies that will promote sustainable agriculture and food systems in Africa. The theme of AMASA 2022 conference: "Strengthening Capacity for Sustainable Agriculture and Food Systems in Africa" is well befitting the challenges many countries in Africa are facing of declining agricultural productivity and food insecurity.

The discussions during this conference are focused on the latest ideas and appropriate solutions and technologies that can enhance sustainable agriculture and food systems in Africa. The discussions are aimed at creating a voice for African academies by focusing on evidence-based research that will help policy makers put science, technology and innovation at the front core of national and continental development. The outcome of this will boost Africa's capacity to sustainably meet the food and nutrition security for the growing population and enable the continent to trade better within itself and into the regional and international markets.

The need and opportunity to improve agricultural productivity will require synergy with other related investments particularly setting an enabling policy environment, capacity building and communication. The science academies, universities and research institutions in the continent will endeavor to promote technology-led investments in sustainable agriculture by strengthening integrated skills development and entrepreneurial capacity to stimulate commercial financing in agriculture.

To successfully achieve sustainable agriculture in the continent the science academies, universities and research institutions in Africa will be encouraged to promote agricultural productivity to improve the livelihoods of the farming communities and improve their food and nutrition security. This will require a transformative change on how the research outputs are shared, delivered and communicated.

The delegates in the AMASA 2022 Conference have come up with the following recommendations:

(i) The respective governments should fund the science academies to provide a platform and entry point for African researchers to spearhead the research-policy and practice in Africa. Currently there are 28 active academies with qualified researchers to take the African agenda forward;

(ii) The African institutions should demonstrate the capacity and willingness to work and collaborate with the donor funding agencies and partners. The African governments should provide updated free access to data banks for universities and other research-based institutions including national science who are involved in research for sustainable development. The African Governments should enhance and strengthen proper frameworks for data protection and management to allow institutions to share and access data as public goods;

(iii) National Science Academies to tailor make communication strategies for the different target audiences; for example the use of policy champions as change agents;

(iv) 'National Science Academies' in Africa should coordinate research activities in the region and be empowered by their respective governments in running the activities to enable communication. Strengthening science communication through delineation of clear roles and responsibilities in delivering of agricultural and food systems agenda;

(v) The African Governments should put structures in place to enhance research activities; for example, introduction of the reward system that gives credit to researchers. The reward arrangement should be timely and prompt and should be factored in the budget of the particular research;

(vi) The institutions of higher learning expand from theoretical training with focus on graduates to more commercialization of the research products and knowledge by maximizing partnerships with industry and institutionalization of intellectual property rights (IPR). This will require establishment of innovation hubs;

(vii) The African countries should conduct a more thorough and holistic analysis of the national innovation systems and creation of science innovation hubs (funded by the governments) like has been done by Rwanda, Ethiopia, Uganda and Zambia to mention a few rather than focusing on the linear and piece-meal innovation systems;

(viii) Specific country public policies and strategies for biotechnology and emerging science technology development should be defined by clearly identified public policy objectives; and

(ix) Biosafety Appeal Board in Kenya needed to be fully constituted to adjudicate the appeals arising from adaptation of biotechnology in the country. The lessons learned from Kenya to be shared with other countries.

Appendix 2: GM Crops as a Viable Option in Addressing Food Insecurity in Africa

Press release 2

African agricultural scientists under the auspices of the Network of African Science Academies (NASAC) have been meeting in Nairobi, Kenya, to discuss and draw recommendations on how the continent can strengthen her capacity for sustainable agriculture and food systems. More than 90 experts from 25 national science academies, including the Kenya National Academy of Sciences attended the meeting which took place from 28th – 30th November 2022.

Far-reaching recommendations towards addressing the run-away food crisis in Africa were adopted; among them the need for African countries to embrace and tap into the huge potential of modern agricultural biotechnology in improving agricultural productivity.

We note that the continent has been embroiled in polarized debate around genetically modified organisms (GMOs) – which are products of modern biotechnology. The debate is even hotter here in Kenya following the lifting of a decade-long ban on importation and use of genetically modified foods in Kenya. The debate has even played out in the law courts, and most recently the High Court has issued orders suspending importation and distribution of GMOs.

GMO facts

As NASAC, we wish to state the following facts:

Approved GM products are safe. Scientific authorities around the world, such as the U.S., the National Academy of Sciences, United Nations Food and Agriculture Organization, World Health Organization, American Medical Association and the American Association for the Advancement of Science, have analyzed thousands of scientific studies and concluded that GM food crops do not pose any risks to people, animals or the environment.

Commercialized GM crops have a history of safe use. GM crops have been grown commercially since 1996 and are proven to be a highly successful farm tool delivering production, environmental and safety benefits. Foods from biotech crops have also been eaten for twenty five years with no verified health problems being reported.

GMOs undergo stringent safety assessment before approval. Research on GM crops, for instance, has to be reviewed and approved in accordance with national and international science protocols. Biotech crops under research are subjected to different levels of assessment before they are approved for commercial cultivation.

GM crops on the market today have the same nutrition and composition as non-GM crops. Food from GMOs is digested in the body the same as food from non-GM crops. For example, GM maize is nutritionally the same and digested the same as non-GM varieties.

More than 70 countries have adopted biotech crops. More than 190 million hectares of biotech crops are grown globally. Developing countries grew 56% of the global biotech crop area compared to 44% for industrial countries.

Biotech crops contribute to food security, sustainability, and climate change solutions: With 25 years of commercialization, there is demonstrated evidence that GM crops are more productive than conventional varieties. They have increased productivity by 822 million tons valued at US$224.9 billion. GM crops have also contributed towards biodiversity conservation and environment safety through significant reduction on pesticide application on crops and carbon emissions.

Most African countries, including Kenya, have enough biosafety capacity to regulate GM research and products. Kenya and many other African countries have in place competent national biosafety agencies that carry due diligence in assessing safety of GM products. Kenya, and a number of other African countries, are signatories to the Convention on Biological Diversity (CBD) and parties to the Cartagena Protocol.

African countries have scientific infrastructure and human capacity needed for research and development of biotech crops. For instance, in Kenya, there are over 100 scientists engaged in agri-biotech research and development activities countrywide, with 45% of these scientists working in the public sector. Biosafety facilities for modern biotechnology include a Level II Greenhouse at the Kenya Agricultural and Livestock Research Organization (KALRO) and the Plant Transformation Laboratory at Kenyatta University.

The Worsening Food Situation:

As we debate about GMOs, the drought situation continues to worsen in twenty of the 23 ASAL counties in Kenya. The situation is replicated in most parts of Africa. According to the Food and Agriculture Organization of the United Nations (FAO), two in every 10 people on the continent are food insecure. Shockingly, more than 100 million Africans face acute food insecurity.

In Kenya, the number of people in need of humanitarian assistance currently stands at 4.35 million based on the 2022 Long Rains Food and Nutritional Security Assessment Report. The situation is worsening in the livestock sector too with more than 50 feed manufacturers closing and farmers downsizing their animals. All these measures are compounding the food insecurity situation.

In this regard, science academies in Africa recommend adoption and commercialization of approved crops as one of the sustainable options in addressing food insecurity and improving livelihoods of the population.

Recommendations:

In order to enhance acceptance and adoption of GM crops in our Africa countries, we propose the following recommendations:

(i) Scientists and the media should lead from the front in sensitizing the public and combating widespread misinformation, misperceptions and myths about GMOs;

(ii) There is a need for sound political leadership that appreciates the vital place of science in addressing climatic challenges and food insecurity. It is unfortunate that the GMO debate in Kenya has taken a political angle; and

(iii) Overlaps in biosafety regulatory and policy frameworks in Africa need to be addressed to enhance the approval process of GM products.

Appendix 3: AMASA 2022 Organizing Committee

1. Prof. Ratemo W. Michieka -Chairman, KNAS Chairman
2. Prof. Paul Baki -Member, KNAS
3. Dr. JPR Ochieng'-Odero -Member, APHRC
4. Prof. Norbert Hounkonnou - Member, NASAC President
5. Ms. Jackie Kado -Member, NASAC
6. Walter Langat -Member, ISAAA AfriCenter
7. Prof. Vasey Mwaja -Member, KNAS
8. Prof. Josephine Ngaira -Member, KNAS
9. Prof. Cecilia M. Onyango -Member, KNAS
10. Dr. Eliud Musotsi -Member, Min. of Education
11. Benard Magudha -Member, NASAC
12. Dr. Joash Migosi -Member, KNAS
13. Ms. Fatuma Achieng -Member, NASAC
14. Ms. Noel Abuodha -Member, KNAS
15. Ms. Elizabeth Andrew -Member, NASAC
16. Edward Ayienda -Member, KNAS
17. Patrick Amboka -Member, APHRC
18. Bernard Mutui -Member, KNAS

Appendix 4: **Conference Programme**

DAY ONE

MONDAY, NOVEMBER 28TH 2022

TIME	ACTIVITY	TOPIC	FACILITATORS
08:30 - 09:00	**Registration**		**KNAS/NASAC**
09:00 - 09:10	Plenary	Welcome Remarks	Prof. Paul Baki Hon. Secretary, Kenya National Academy of Sciences (KNAS)
09:10 - 10:00	Plenary	OFFICIAL OPENING CEREMONY National Anthem (Kenya & EAC) Opening Remarks and Speeches Goodwill Messages from Partners	Prof. Ratemo W. Michieka, Chairman KNAS & Chairman AMASA 2022 Organizing Committee Prof. Norbert Hounkonnou, President NASAC - Benin NACOSTI, IAP, APHRC, INGSA-Africa, ISAAA/ALSK Hub, NRF
10:00 – 10:30	Plenary	Guest of Honor	**Amb. Simon**

		Remarks	**Nabukwesi** Principal Secretary, SDUER MoE, Kenya
10:30 - 11:00		What is Needed to Generate the Capacity to Direct Sustainable Food System Transformation in Africa?	**Keynote Address**: Prof. Iain Wright, ILRI Director General - Kenya
11:00 - 11:15	Group Photograph		KNAS
11:15 - 11:30	**HEALTH BREAK**		
11:35 - 11:40	**Day 1: Opening Session**		**KNAS**
11:40 - 13:00: SESSION I - SCIENCE AND EMERGING TECHNOLOGIES IN AGRICULTURE **Chair: Prof. Rajaâ Cherkaoui El Moursli – Morocco**			
11:40 – 12:10	Plenary	Gene Editing Technology for Sustainable Agriculture in Africa	**Main Speaker**: Prof. Florence Wambugu, Africa Harvest - Kenya
12:10 - 12:30		Enhancing Food Production in Africa Through Utilization of Nuclear Techniques	Dr. Yousuf Maudarbocus - Mauritius
12:30 - 12:50		Utilizing Modern Biotechnology to Develop Virus Resistant Cassava for Smallholder Farmers	Prof. D.W. Miano, University of Nairobi - Kenya

12:50 - 13:10	Panel discussion	• Prof. Mathews M. Dida - Kenya • Prof. Kavwanga Yambayamba – Zambia • Prof. Habiba Chaabouni - Tunisia	
13:10 - 13:30	Q&A Session		
13:30 –14:30	**LUNCH BREAK**		
13:30 -14:30	**POSTER VIEWING SESSION OPENS - KNAS**		
14:30 - 17:00: SESSION II - CLIMATE CHANGE, ENVIRONMENT AND AGRICULTURE **Chair: Ms. Jackie Kado, NASAC - Kenya**			
14:30 - 15:00	Plenary	Protecting Human Health from Climate Change in Africa	**Main Speaker** Dr. Deoraj Caussy, Mauritius – Lead researcher for NASAC CCH Report
15:00 - 15:20		Achieving Food Security Under Climate Change: Case of Forestry and Land Restoration	Dr. Jesse Owino - Kenya Forestry Research Institute (KEFRI)-Kenya
15:20 - 15:40		Agro-pastoralists Determinants of Adaptation of Crop-Livestock Smart Technologies to Climate Change in Marsabit, Kenya	Ms. Anne Gudere - Kenya Agricultural and Livestock Research Organization - Kenya
15:40 – 16:10	Panel Discussion	• Prof. Josephine Ngaira - Kenya • Prof. Bi Guimé Crépin – Cote D'Ivore • Prof. Charles Nhachi - Zimbabwe	
16:10 – 16:40		Q&A Session	

16:40 – 17:10	Plenary	Dr. Philip Osano Stockholm Environmental Institute (SEI)
17:10 – 17:20	**Day 1 Closing Session - KNAS**	
17:20 - 17:40	**HEALTH BREAK & POSTER VIEWING**	

18:00 - 21:00: GROUP DINNER HOSTED BY UGANDA NATIONAL ACADEMY OF SCIENCES (UNAS)

DAY TWO

TUESDAY, NOVEMBER 29TH 2022

08:45 -09:00	**Day 2 Opening Session**	**KNAS**	
09:00 - 11:00: SESSION III - SCIENCE DIPLOMACY, COMMUNICATION, POLICY ANALYSIS ON AGRICULTURE AND FOOD SECURITY **Chair: Prof. Nobert Hounkonnou - President NASAC, Benin**			
09:00 - 09:30	Plenary	Science Communication: A key Enabler of Sustainable Agriculture and Effective Food Systems in Africa	**Main Speaker:** Dr. Margaret Karembu – ISAAA AfriCenter
09:30 - 09:50		Climate Change, Politics and Economics Intersection in Zimbabwe's Food Insecurity Crises of 2019-2020	Prof. Philani Moyo University of Fort Hare - South Africa
09:50 - 10:10		Regulation of Biotechnology and Emerging Technologies for Improved Agricultural Productivity in Kenya: A Case Study of GM Crops	Prof. Dorington Ogoyi - Technical University of Kenya

10:10 - 10:40	Panel Discussion	• Prof. Ishmael Masesane – Botswana • Prof. Irvy Gledhill – South Africa • Prof. David Miano – Kenya
10:40 – 11:10	Q&A Session	
11:10 - 11:30	**HEALTH BREAK & POSTER VIEWING**	

11:30 -13:00: SESSION IV - CAPACITY BUILDING, SCIENCE TECHNOLOGY & INNOVATION (STI), RESEARCH PRODUCTS COMMERCIALIZATION **Chair: Ms. Bibiana Iraki – ISAAA AfriCenter, Kenya**			
11:30 – 12:00	Plenary	Role of Agri-Innovations in Building Sustainable Agriculture in Africa	**Main Speaker**: Dr. Emmanuel Okogbenin – African Agricultural Technology Foundation (AATF)
12:00 - 12:20		Moving Research to Commercialization: A Case of Biotech Crops	Godwin Lemgo, Bayer Crop Science Africa - Kenya
12:20 - 12:40		The Role of Supply Chain Management in Building a Sustainable Competitive Advantaged Agribusiness to Food Security in Developing Economies	Dr. Albert Washington Ochung Tambo – Maseno University
12:40 –13:10	Panel Discussion	• Dr. Susan Musembi - Kenyatta University • Dr. Silas Obukosia - AUDA-NEPAD, Kenya • Joshua Takalimane - Lesotho	
13:10-13:30	Q&A Session		
13:30 -14:30	**LUNCH BREAK & POSTER VIEWING**		

14:30 - 17:30: SESSION V - RESEARCH CAPACITIES OF AFRICA'S UNIVERSITIES AND RESEARCH INSTITUTES **Chair: Dr. Evelyn Gitau, Director of Research and Related Capacity Strengthening/Interim Director of Research - African Population and Health Research Center (APHRC)**			
14:30 - 15:00	Plenary	Research Capacities of Africa's Universities and Research Institutes	**Main Speaker**: Dr. Catherine Kyobutungi, APHRC -Kenya
15:00 - 15:20		Gates Catalyze Impact Project	Dr. Julius Sindi, APHRC - Kenya
15:20 – 15:40		Capacity Gaps in African Universities and Research Institutions	Dr. JPR Ochieng'-Odero, APHRC - Kenya
15:40 – 16:10	Panel Discussion	• Prof. Abdess Salem Saumtally - Mauritius • Ms. Charity Musembi - NACOSTI, Kenya • Ms. Jackie Kado - NASAC, Kenya	
16:10 – 16:30	Q&A Session		
16:30 – 16:45	**HEALTH BREAK & END POSTER VIEWING**		
16:45 – 17:15	**Day 2 Closing**	• Conference Rapporteurs: Wrap-up of the Conference (Expected outcomes, Recommendations, Policy Briefs) • Handing Over to the Academy Hosting AMASA 2023	• Prof. Vasey Mwaja, KNAS • Walter Langat, ISAAA AfriCenter • Patrick Ombaka, APHRC • Dr. Joash Migosi, KNAS

18:00 – 21:00	GROUP DINNER HOSTED BY TWAS-SAREP/ASSAf

VI. POSTER PRESENTATION SESSION

Chair: Prof. Vasey Mwaja, Editor-in-Chief, Kenya National Academy of Sciences

Poster No.	Name of Presenter	Institution	Title of the Poster
1	Prof. Habiba Bouhamed Chaabouni	Tunisia Academy of Sciences, Arts & Letters,Tunisia	Science and Technology for the Benefit of Food Security, the Genetics Contribution
2	Prof. Mathews M. Dida	Maseno University, Kenya	Lessons Learned in Maize Breeding Using Kenyan Landrace Derived Inbred Lines
3	Prof. Ethel Oranga Monda	Kenyatta University, Kenya	Improved Food Security, Safety, and Incomes Through Integrated Pre-and Post-harvest Aflatoxin Contamination Control in Groundnuts
4	Benjamin Kinyili	Kenya Forest Service/Kenyatta University, Kenya	Influence of Agroforestry Adoption on Ecosystem Services and Livelihood for Smallholder Farmers in Machakos County, Kenya
5	Ms. Mercy Muthoni	Nairobi Water & Sewerage Company/ Kenyatta University, Kenya	Ecological and Economic Benefits of Integrating Fish into Rice Farming at Mwea Irrigation Scheme in Kirinyaga County, Kenya

6	Dr. Joash Migosi	University of Nairobi, Kenya	Causal Model and Research Productivity of Agricultural Researchers: Lessons from Recent Literature in Kenya
7	Dr. Eliud Musotsi and Dr. Rose Shikuri	Ministry of Education/ Masinde Muliro University of Science and Technology, Kenya	The Contested Meanings of Development Among the Iraqw Tribe of Tanzania
8	Prof. Samuel Obuchi	Moi University, Kenya	Mitigation of Linguistic Challenges in Communicating Agricultural Content for Sustainable Development in Kenya

DAY THREE

WEDNESDAY, NOVEMBER 30TH 2022

09:00 – 9:30	**Day 3 Opening Session**	**NASAC**	
09:30 - 13:00 International Network for Governmental Science Advice - Africa Chapter - INGSA-Africa **Chair: Dr. Richard Glover – RPO, INGSA-Africa**			
09:30 – 10:15	Plenary	**Keynote address**: Science Advise in the Post-COVID Era	**Main Speaker**: Prof.Abhimanyu Veerakumarasivam Chair, INGSA-Asia
10:15 – 10:45	Panel Discussion	Open Discussions and	Moderator: Dr. Oladoyin

		Q&A session	Odubanjo Chair, INGSA-Africa
10:45 – 11:15		**HEALTH BREAK**	
11:15 – 13:00	Case Study	Discussion in groups	Coordinators: • Enock Musungwini, INGSA-Africa SC • Dr. Richard Glover, RPO INGSA-Africa
13:00-14:00		**LUNCH BREAK**	

14:00 - 17:00	**NASAC ANNUAL GENERAL ASSEMBLY MEETING** **Chair: Prof. Norbert Hounkonnou, President, NASAC**	
14:00 - 17:00	Plenary (CLOSED MEETING)	18th General Assembly Meeting of NASAC

Appendix 5: Conference Participants

NAME	TITLE	AFFILIATION	COUNTRY
1. Abdess Salem Saumtally	Prof.	MAST	Mauritius
2. Abhi Veerakumarasivam	Prof.	INGSA	Malaysia
3. Aderito Pais da Cunha	Prof.	Angolan Academy of Science (AAS)	Angola
4. Ahmed M. Gabr	Dr.	Academy of Science of Egypt/ ASRT	Egypt
5. Angie Olanipekun	Ms.	NAS	Nigeria
6. Anne Gudere	Ms.	Kenyatta University	Kenya
7. Arouna Ouedraogo	Prof.	ANSALBF	Burkina Faso
8. Artz Luwanda	Dr.	MAS	Malawi
9. Asifa D. Nanyaro	Dr.	TAAS	Tanzania
10. Benard Magudha		NASAC	Kenya
11. Benard Ndambuki		MoE-SDHER	Kenya
12. Benedetta Chacha		DRST	Kenya
13. Bernard Mutui		KNAS	Kenya
14. Bi Guime Crepin	Prof.	ASCAD	Ivory Coast
15. Bibiana Iraki	Ms.	ISAAA AfriCenter	Kenya
16. Boniface Gitahi		MoE-DRST	Kenya
17. Caroline Kiio	Ms.	NASAC	Kenya

18. Caroline Owade		MoE-SDUER	Kenya
19. Catherine Kyobutungi	Dr.	APHRC	Uganda
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0250 – 8265 ISSN CODEN KSTSDG