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AWC STRATEGY

A NEW FOOD SECURITY MODEL FOR AFRICA

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Agricultural production is heavily reliant on soil fertility and water availability, both of which are increasingly compromised in the African rainfed production systems, which encompass a significant portion of arable land. Moreover, the continent faces the adverse effects of climate change, including rising temperatures, droughts, and unpredictable rainfall patterns, all of which negatively impact agricultural output. The interplay between agriculture, water, and climate is complex and multifaceted. Given that African economies heavily rely on agriculture, the vulnerability to climate change is particularly high. Additionally, widespread issues such as low soil fertility and water scarcity further exacerbate the challenges. Currently, there is a limited understanding of climate adaptation and mitigation strategies, and targeted technological development requires increased investment to combat food insecurity, poverty, and environmental degradation.

The urgency of achieving food and nutritional security and sustainability necessitates transforming agri-food systems by adopting new models that enhance productivity, restore soil health, improve water usage efficiency, preserve biodiversity, reduce greenhouse gas emissions, sequester carbon in the soil, and promote the social wellbeing and livelihood of farmers.

The AWC (Agriculture, Water, Climate) strategy was collaboratively developed using a bottom-up approach, consisting of six phases: diagnosis, strategic foresight, benchmarking, organization and governance structures, alignment of key strategic areas, and formalization is structured around six strategic pillars and five enablers, which serve as the foundation for its implementation. The six strategic pillars encompass the key focus areas of the strategy and guide its direction:

1. Climate Change
2. Science of Phosphorus
3. Water and WEF nexus
4. Agriculture in Drylands & Marginal Environments
5. Agri-food Systems & Value Chains for Rural Development
6. Sustainable Intensification of African Agriculture

To expedite the achievement of desired outcomes, five strategic enablers have been identified:

1. Digitalization & Agritech
2. Gene Editing & Biotechnology
3. Innovation & Entrepreneurship
4. Learning & Education
5. Trans-disciplinarity, Scaling & Extension

Together, they generate outputs and innovations that enhance agricultural productivity, promote food and nutrition security through sustainable intensification of staple crops, foster inclusive agri-food systems value chains for rural development, address soil degradation and water scarcity for environmental sustainability, and advance climate action. This comprehensive and integrated approach is geared towards harnessing innovation to support agriculture, natural resource management, and rural development in Africa.

1. Strategic pillars (SP)

SP I: Climate change

Challenges

Recent changes in the climate are widespread, rapid, and intensifying. Africa needs to adapt to unavoidable climate change impacts. Limiting global warming to 1.5 °C is expected to substantially reduce damage to African economies, agriculture, human health, and ecosystems compared to higher levels of global warming. Technological, institutional, financial, and leadership factors are major barriers to climate change adaptation feasibility in Africa. The major challenges include maladaptation, a crucial problem for food security and agricultural development; the increase in frequency and severity of extreme events such as droughts, heat waves, and floods; poor soil health (negative impacts on carbon sequestration); and lack of collaboration and favorable framework for climate finance

Innovation opportunities

New science and innovation opportunities include: improving the quality and accessibility to climate data; production, packaging, and disseminating tailored climate information and services; developing an enabling environment for coproduction of knowledge as well as its transfer and conducive policies; multi-stakeholder climate literacy and advocacy; assessment of climate impacts and vulnerability; climate change adaptation metrics for adaptation monitoring, evaluation, and efficiency; evidence-based prediction and monitoring methodologies such as early warning systems; and defined climate finance.

Strategic priorities

• Developing climate modeling capabilities to enhance the prediction of agricultural production and inform the development of adapted technologies.

• Generating and disseminating climate-smart agriculture technologies and policy options.
• Producing scientific information to support adaptation and decision-making processes.
• Developing climate services that provide valuable support and guidance for Africa.
• Building capacity in climate adaptation and mitigation research through targeted training and education initiatives

Expected short and long-term impacts

The AWC strategy aims to improve the understanding of climate change dynamics in Africa, enabling the agriculture sector to effectively respond to challenges through risk management, mitigation, and adaptation. The development of sophisticated modeling systems will enable more accurate predictions of changes in extreme events, including their magnitude, duration, and extent. Furthermore, gaining a deeper understanding of the social, economic, and ecological factors influencing adaptive capacity and resilience in agri-food systems will enhance the ability of stakeholders to adapt to climate change.

SP 2: Science of Phosphorus

Challenges

Phosphorus (P) sustainability is a pressing global concern for future food and nutrition security. With the increasing world population, limited arable land, and environmental degradation concerns, there is a critical need to produce more food while minimizing P losses and preserving the environment. In Africa, P deficiency in soils is a significant challenge, demanding sustainableP-use solutions. Addressing these challenges requires interdisciplinary collaboration between chemical, bio-physical, and socioeconomic sciences.

Innovation opportunities

Exciting science and innovation opportunities lie in enhancing our understanding of P biogeochemical cycling, improving P management strategies, and developing products that enhance P use efficiency. This includes exploring molecular environmental science for P flow modeling, elucidating rhizospheric mechanisms and P availability, improving P-use efficiency from different sources, and engaging policymakers to drive change.

Strategic priorities

• Advancing our understanding of P biogeochemical cycling.
• Investigating plant-microorganism interactions for enhanced P acquisition.
• Exploring (bio)technologies to increase soil P availability.
• Developing P fertilizer technologies tailored to specific soil conditions and cropping systems, along with fertilizer recommendation guidelines.
• Designing cropping systems that optimize P use efficiency, biomass production, and sustainability.
• Developing policies to support improved P use efficiency.

Expected short and long-term impacts:

Enhanced knowledge of biogeochemical P cycling and plant-soil-microorganism interactions will revolutionize nutrient management and P behavior understanding.

This will lead to improved fertilizer recommendations for specific soil conditions and cropping systems, promoting P availability and fertilizer technologies. Ultimately, increased P use efficiency will contribute to sustainable and cost-effective food and feed production.

SP 3: Water, Irrigation, and WEF Nexus

Challenges

Water scarcity poses a significant constraint on food production and security in North and Sub-Saharan Africa. Anthropogenic water use and the impact of climate change exacerbate these challenges. Addressing water reuse presents a promising solution. Developing low-cost and nature-based wastewater treatment solutions is essential. To overcome these challenges, a comprehensive reevaluation of agricultural water management is necessary. The interconnection between water, energy, and food systems is vital for food security, nutrition, and livelihoods. Innovative strategies and management options are required to ensure sustainable productivity and address water and energy use in agricultural systems.

Innovation opportunities

Promising science and innovation opportunities include integrated water resources management through improved technologies, AI-driven decision support tools, smart irrigation practices, efficient water use accounting and auditing, strategic utilization of groundwater resources, advanced rainwater harvesting techniques, system dynamics modeling, improved water technologies like renewable energy-powered desalination, wastewater treatment, and optimization of urban networks to minimize losses.

Strategic priorities

- Drive scientific innovation, research, and development in integrated water management, utilizing advanced technologies, modeling, AI, desalination, participatory approaches, and partnerships.
- Foster innovative water science and technology education through engaging teaching methodologies.
- Establish a dedicated Business Unit for strategic water studies.

Expected short and long-term impacts

The proposed research and development program aims to achieve measurable impacts on sustainable solutions within the WEF nexus, enhancing the resilience of irrigated and rainfed agri-food systems. IWRI's focus on efficient water management strategies benefits all water users. By promoting government policy leadership, enabling institutional frameworks, and fostering strong public-private partnerships (PPP), investments in water research and development, infrastructure, and business enterprises can be increased. IWRI's long-term vision includes establishing an African Water Consortium.

SP 4: Agriculture in Drylands, Saline, and Marginal Environments

Challenges

Drylands cover two-thirds of the African continent, with three-quarters of these areas utilized for agriculture. These production systems encompass rainfed and irrigated agriculture, rangelands, and saline agro-ecosystems, all of which incorporate crop-livestock farming. However, these fragile

and highly degraded drylands face numerous challenges, including land degradation, desertification, declining soil fertility, loss of biodiversity, water resource depletion, pollution, and salinization. Climate change further exacerbates these challenges with rising temperatures, erratic and reduced rainfall, and increased water deficits and scarcity. Additionally, institutional hurdles such as policy and legal issues hinder the sustainable development of dryland agriculture.

Innovation opportunities

Promising science and innovation opportunities in this field include the utilization of technologies like satellite imaging, digital sensors, climate-smart agricultural practices combined with precision agriculture and digitalization. Advances in plant and animal genomics and advanced data analytics can also contribute. Integrated approaches encompassing crop-rangelandslivestock systems, conservation agriculture, agroforestry, diversification of food production systems, and the restoration and sustainable management of natural resources, particularly soil health, water, and agro-biodiversity, present additional opportunities.

Strategic priorities

• Implementation of smart farming or precision agriculture technologies to enhance water and nutrient use efficiency.
• Integrated management of soil, crops, and water resources.
• Promotion of rainwater harvesting, conservation agriculture, and crop diversification.
• Development of climate-resilient agroforestry and crop-livestock systems.
• Establishment of an observatory for dryland agricultural systems in targeted areas.

Expected short- and long-term impacts

The proposed research and development initiatives will bring about transformative impacts on farmers, agro-pastoralists, and communities by establishing sustainable and resilient food, land, and water systems. Governments at all levels must foster enabling environments and strong public-private partnerships to increase investments in research and development, infrastructure, and business enterprises, scaling up the adoption of climate-smart and resilient technologies.

SP 5: Agri-food Systems and Value Chains for Rural Development

Challenges

The farming systems in the Rhamna Province and other Phosphate production regions in central Morocco primarily revolve around barley-livestock (sheep, goats, and cattle), poultry, olives, and rangeland systems. However, there is untapped potential to develop other crops such as cactus, carob, and capers.
The region faces significant challenges, including a high illiteracy rate, poverty, inadequate investment in agricultural inputs, unemployment, insufficient social services and infrastructure, and rural exodus. Climate change and erratic rainfall further exacerbate the deficit of irrigation resources, leading to rangeland degradation, erosion, and desertification.

Strategic priorities

• Enhancing agriculture sustainability and the functioning and profitability of agriculture value chains.

• Collaborative efforts to leverage science and new technologies to improve the quality of life in rural areas and the economic performance of the rural population.
• Launching «Smart Douars» initiatives (Living Labs for testing locally developed solutions) using digital transformation tools.
• Capacity building, fostering innovation and entrepreneurship, with a particular focus on empowering women and youth as drivers of rural transformation.

Expected short-term impacts

These include promoting an entrepreneurial culture through the education system, fostering digital literacy, supporting the creation of new businesses and attracting investors, promoting public-private partnerships, facilitating learning from successful experiences, and diversifying funding sources for new business projects.

SP 6: Sustainable Intensification of African Agriculture

Challenges

Despite decades of research and development (R4D), agriculture in Sub-Saharan Africa (SS Africa) is still predominantly characterized by lowinput, subsistence food crop production on small rainfed land holdings that rely on manual labor. The challenges of improving agricultural productivity and food security through intensification are multifaceted and interconnected. While there is potential for the continent to feed its population and even become a net food exporter, understanding the drivers and constraints of African agriculture's development and how the region can intensifying farming in economically and environmentally sustainable ways to meet its rapidly rising and shifting food demands is crucial for designing impactful and scalable research in the future.

Innovation opportunities

Developing viable solutions for sustainable intensification, alongside addressing the yield gap, requires integrating context-specific information and knowledge on socioeconomic, policy, market, and livelihood aspects.
Opportunities include improving soil health and preventing soil degradation, adapting to climate change, enhancing access to modern agricultural technologies, developing infrastructure, establishing connections between producers and input/output markets through both physical and institutional infrastructure, fostering public private partnerships, reducing inequalities, and improving governance.

Strategic priorities

• Developing an integrated framework to prioritize specific agroecologies and farming systems based on their potential and expected return on sustainable intensification investments.
• Establishing context-specific impact pathways for sustainable intensification.
• Identifying potential trade-offs and synergies of intensification options.
• Developing and promoting best agronomic management practices for cereal-based farming systems in Morocco and across Africa.
• Establishing strong partnerships with relevant CGIAR Regional Initiatives and their stakeholders in Africa.

Expected short- and long-term impacts

These include the development of an integrated framework that prioritizes specific agroecologies and farming systems based on their intensification potential and expected return on investments, the promotion of best agronomic practices to bridge yield gaps in important staple crops in Africa, and the establishment of robust partnerships with a wide range of stakeholders along the research-todevelopment continuum.

2. Enablers

Enabler 1: Digitization and Agritech

Challenges

For innovation to effectively contribute to the Sustainable Development Goals (SDGs), it must address key areas such as productivity, resource efficiency (particularly land and water), food system adaptation to climate change, equity, and sustainability. It should also aim to uplift smallholder farmers from poverty, reduce their vulnerability, and enhance their capacity to actively participate in their country's economy. While the commercial farming sector in Africa has started adopting innovative and precision agriculture technologies, a major challenge lies in adapting transformative innovations and modern tools for smallholder use.
Designing technology and innovation solutions that cater to the needs and scale of smallholder farmers across Africa remains a significant hurdle.

Innovation opportunities

Digital innovation should not only focus on precision agriculture technologies but also agri-food system innovation for markets and value chains. There is a need for innovations in agricultural product processing, valorization, and post-harvest management. Additionally, innovations that facilitate market linkages, enable labeling and traceability, promote bio-packaging, and manage waste throughout the value chains are crucial. Building on investments in the African Supercomputing Data Center, state-of-theart crop phenotyping platforms and facilities, and coding schools, the digital innovation and Agritech programs at UM6P have ample opportunities to leverage robotics, big data, artificial intelligence, and advanced remote sensing technologies. These technologies can generate new precision agriculture applications and address questions regarding the contribution of various agricultural technologies to more efficient and sustainable practices.

Enabler 2: Gene Editing and Agricultural Biotechnology

Challenges

Genome-editing tools offer advanced biotechnological techniques that enable precise and efficient targeted modification of an organism's genome. These technologies provide a level of accuracy and predictability previously unavailable for modifying crop genomes. They are also accessible and cost-effective. Genome editing has the potential to improve various crop plants, including those essential for food security in Africa. Over 40 crops across 25 countries are already being enhanced through genome editing, primarily focusing on agronomy, food and feed quality, and abiotic stress tolerance. Countries like Nigeria and Kenya have invested significantly in CRISPR/Cas9 technology across different sectors. Urgent investments in gene editing platforms throughout Africa are needed to drive future advancements in health and food security.

Innovation opportunities

The emerging science and innovation opportunities in gene editing include gene editing systems and DNA repair to remove negative elements associated with undesirable traits and enhance the function of target genes. CRISPR/Cas9 can be applied in crop breeding and animal improvement programs to accelerate the delivery of benefits to smallholder farmers. It also holds potential in bio-industrial applications for biofuels, healthcare, therapeutic advancements, and cancer therapies.

Strategic priorities

- Establishing a platform for genome editing technologies, utilizing CRISPR-Cas-based gene editing in bio-industrial applications involving bacteria, fungi, yeasts, and algae.
- Accelerating the application of omics for technology transfer in Africa.
- Engaging with policymakers to address regulatory challenges and ethical concerns surrounding genome editing.

Expected short- and long-term impacts

The progress made in the development and application of genome-editing tools positions them to play a crucial role in accelerating costeffective crop breeding to meet the growing global demand for food. Given the challenges posed by climate change, there is a need for flexibility and innovation in enhancing crop resilience and production systems. The future impact of genome-edited crops relies

on effective governance of national and international regulatory, policy, and socioeconomic frameworks.

Enabler 3: Innovation and Entrepreneurship

Challenges

Scientific research and the audacious innovations that result from it, are a source of attractiveness for investors around the world betting on Africa, and the challenge is to give a new generation of African entrepreneurs the chance to challenge the future and to rise in power of entrepreneurial capacity. Innovation and entrepreneurship (I&E) is one of the driving forces at UM6P, which sees African youth creativity as a springboard towards new technological solutions capable of responding to the African and even global development challenges.

Enabler 4: Education 4.0

Challenges

Society has undergone significant transformations in recent decades, yet higher education teaching has not always kept pace with these changes. Many universities still rely on the one-way transmission of knowledge from teachers to students. Education 4.0 embraces new technologies and aims to provide personalized learning experiences through dynamic systems that continuously adapt and modify content based on each student's learning pace. Education 4.0 promotes innovative pedagogical approaches that foster the acquisition, evaluation, and enhancement of future-oriented skills such as complex and systemic thinking and problem-based learning. UM6P is committed to embracing Education 4.0, with a forwardlooking approach to research and education that emphasizes innovation, experimentation, and the pursuit of excellence.

Enabler 5: Transdisciplinarity and Scaling

Challenges

Addressing the complex challenges of sustainable development in Africa and beyond requires the application of transdisciplinary approaches. The complexities associated with increasing agricultural production in the face of water scarcity and climate change necessitate a reevaluation of knowledge creation and utilization processes. Enhanced collaboration among scientists from diverse fields and resources opens opportunities for mutual enrichment and the development of innovative problem-solving approaches that can lead to transformative change through scaling up and out.