Fostering resilient rice-based agri-food systems for nutrition and health in Africa

Africa Rice Center (AfricaRice) – Annual Report 2020

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Citation:

Africa Rice Center (AfricaRice). 2021. Africa Rice Center (AfricaRice) *Annual Report 2020: Fostering resilient rice-based agri-food systems for nutrition and health in Africa.* Abidjan, Côte d'Ivoire: 32 pp.

ISBN:

Print 978-92-9113-406-9

PDF 978-92-9113-407-6

Writing and editing:

Green Ink (www.greenink.co.uk)

Photo credits:

All pictures are by staff members of AfricaRice, and networks and consortia convened by the Center.

Cover: Farmer completing participatory varietal selection form for red rice varieties, Madagascar (*see* 'Improved and nutritious red rice for Madagascar', *see* page 22).

About Africa Rice Center (AfricaRice)

Africa Rice Center (AfricaRice) is a pan-African Center of Excellence for rice research, development and capacity building. It contributes to reducing poverty, achieving food and nutrition security and improving livelihoods of farmers and other rice value-chain actors in Africa by increasing the productivity and profitability of rice-based agri-food systems, while ensuring the sustainability of natural resources. AfricaRice is a CGIAR Research Center — part of a global research partnership for a food-secure future. It is also an intergovernmental association of African member countries. The Center was created in 1971 by 11 African countries. Today its membership comprises 28 countries, covering West, Central, East and North African regions, namely Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Côte d'Ivoire, Democratic Republic of Congo, Egypt, Ethiopia, Gabon, The Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Madagascar, Mali, Mauritania, Mozambique, Niger, Nigeria, Republic of Congo, Rwanda, Senegal, Sierra Leone, Togo and Uganda. AfricaRice headquarters is based in Côte d'Ivoire. Staff members are located in Côte d'Ivoire and in AfricaRice research stations in Liberia, Madagascar, Nigeria, Senegal and Uganda. For more information, visit www.AfricaRice.org

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AfricaRice

Message from the Board Chair and Director General

The year 2020 was dominated by the COVID-19 pandemic and none of the AfricaRice member countries were spared. Mechanisms to mitigate negative effects of the pandemic on the Center's activities were established, and the Center was also able to provide support to governments' efforts to reduce the negative impacts of the pandemic on the rice value chain.

At the onset of the pandemic, AfricaRice established a COVID-19 working group consisting of focal points in each country where its outreach stations and offices are situated (Côte d'Ivoire, Liberia, Madagascar, Nigeria, Senegal and Uganda). This working group of focal points was led by Ms Maïmouna Diatta (French translator–editor), based at AfricaRice's headquarters in Côte d'Ivoire. The group collected and provided relevant information on the pandemic and made recommendations to management on how to mitigate potential negative effects on the operations of the Center as well as on the health and safety of staff and their families. The lead focal point also interacted with the COVID-19 Centers/Alliances Focal Points network at the System level of CGIAR to share best practices and updates. These measures helped reduce the risk of person-to-person transmission at the workplace. By the end of the year 2020, three staff members had tested positive for COVID-19.

The Director General issued a policy paper on flattening the food insecurity curve with reference to the operations of rice value chains in AfricaRice member states. Based on this publication and others written by AfricaRice scientists and their partners, the Center convened a virtual workshop of the Africa-wide Rice Policy and Economics Task Force, 19–20 May 2020, which aimed at creating a better understanding of the actual and potential impacts of COVID-19 on rice agri-food systems in AfricaRice member countries. This workshop resulted in the recommendation of appropriate policy measures to increase the resilience of rice value chains and achieve food security (*see* page 7).

Several AfricaRice member states established emergency programs to respond to the potential negative effect of the COVID-19 pandemic on food security. Within the programs of various countries, the expertise of AfricaRice in assuring the production of quality rice seed was brought to the fore. The most notable response of AfricaRice in partnership with the Green Innovation Centers of the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ), was the establishment of a flagship project entitled 'COVID-19 Response Rice Seed' (CORIS), approved and funded by the German Federal Ministry for Economic Cooperation and Development (BMZ), which aims to catalyze seed production of climate-resilient varieties and good agronomic practices in partnership with public- and private-sector partners. This project will contribute to the establishment of resilient food supply chains in Burkina Faso, Nigeria, Côte d'Ivoire, Benin, and Mali.

Research and innovation highlights

The following research and innovation activities highlighted in this report reflect, in different ways, the theme of this year's report on fostering resilient rice-based agri-food systems to respond to food security, nutrition and health, and environmental challenges in Africa.

Food security

An assessment of the efforts deployed by 15 African governments to upgrade their domestic rice value chains ten years on from the rice price crisis of 2007/2008 was carried out by AfricaRice and its partners. This assessment coincided with the onset of the pandemic, thus providing an opportunity for AfricaRice and its partners to deliver a set of short- and long-term recommendations for increasing rice value chain resilience in the face of COVID-19 (*see* page 7).

AfricaRice was a major player in the establishment of the Consortium of Rice Seed Enterprises and Millers

(COSEM-Riz) to facilitate the production and delivery of quality rice seed for smallholders and commercial farms, through public–private partnerships (PPPs). What distinguishes this consortium from others is the inclusion of millers, who represent an important element and strong component of COSEM-Riz. Whereas Consortium membership is currently dominated by seed enterprises, its members are committed to reaching out to more millers throughout sub-Saharan Africa in the future (*see* page 9).

With current demographics, Africa will remain a 'youthful' continent for the foreseeable future. Creating job opportunities for youth in the agricultural sector is vital, therefore, and making these jobs attractive to young entrepreneurs is even more so. The contribution of AfricaRice to reaching such an objective is demonstrated by its involvement, over the past 3 years, in a project aimed at creating jobs and entrepreneurship activities for youths along the rice value chain (*see* page 10).

AfricaRice in partnership with a multidisciplinary team from the National Agency for Agricultural and Rural Advice trains and coaches women rice farmers to produce quality rice seeds in the rice sector development hub of Nioro in Senegal. This activity was motivated by the critical need for quality seeds of salinity-tolerant rice varieties recently selected and introduced in Senegal, for sowing on highly saline lowlands that had been abandoned in the past, and to which the farmers were returning (*see* page 11).

In another example, successful trials carried out by the Africa-wide Rice Breeding Task Force, resulted in the release in Niger of four new varieties that show high yield potential, earliness (short cycle), and blast resistance. (*see* page 12).

AfricaRice possess the largest *ex situ* collection of the African cultivated rice (*Oryza glaberrima*, in the world. This collection is held in trust in its genebank and represents international public goods. The Center has a long history of research on the use of traits responsible for the local adaptation of *O. glaberrima.* and continues to demonstrate that this valuable material is best put to use based on knowledge acquired through research on desired traits carried by these accessions (*see* page 13).

The Center is crossing perennial rice varieties of *O. sativa* developed in China with perennial African wild relative *O. longistaminata*, with the aim of increasing field productivity and profitability for farmers. The initial results are quite promising (*see* page 14).

Climate change, environment and natural resources

Water is an increasingly precious commodity on the continent in all contexts (agricultural, domestic and industrial) and is becoming expensive. AfricaRice is pursuing and promoting research on alternate wetting and drying (AWD) to reduce water use for rice production and increase water use efficiency (*see* page 15).

Turning food and chemical waste into fertilizer seems a reasonable option when the waste in question has high levels of nitrogen, potassium, and micronutrients sulfur and sodium. AfricaRice in partnership with a private sector firm, Ajinomoto Co. in Côte d'Ivoire, is assessing the fertilizer value of rice by-products (*see* page 17).

RiceAdvice is a very successful Android-based app developed by AfricaRice, which provides information to farmers on the efficient management of fertilizer in different rice ecologies. The impact of its widescale deployment in Nigeria was assessed by AfricaRice (*see* page 18).

In response to the growing demand for scalable agronomic innovations for sustainable agricultural development, ten CGIAR Centers, including AfricaRice, launched the Excellence in Agronomy 2030 (EiA 2030) initiative in September 2020 (*see* page 19).

Nutrition and health

Diabetes is on the rise, globally, and Africa is not exempted. One potential disease management option is to produce and consume low-glycemic staples. AfricaRice is identifying ways to further reduce the glycemic load in rice, even though it is known that rice is inherently less glycemic than wheat. (*see* page 21).

Red rice, long confined to farmers' home gardens in Madagascar, is making a comeback for its nutritional value. While local landraces are low-yielding and susceptible to cold, AfricaRice and partners have identified three varieties from Korea that could boost production and make traditional red rice marketable and even exportable (*see* page22).

New projects and initiatives

The Rice Biodiversity Center for Africa, installed at the M'bé Research Station in Côte d'Ivoire, was inaugurated in February 2020. The Center is raising the awareness of stakeholders on the need for safeguarding rice diversity and on the role of rice in food security.

AfricaRice initiated efforts to modernize its breeding activities in collaboration with the Excellence in Breeding platform (EiB). This was supported by the establishment of both a One Rice breeding strategy and framework and a One Global Rice Breeding Program to drive the strategy, jointly established with the International Rice Research Institute (IRRI). The

Inauguration of the Rice Biodiversity Center, M'bé, Bouaké, Côte d'Ivoire, 21 February 2020: (left to right) AfricaRice Director General, Dr Harold Roy-Macauley; Minister for the Promotion of Rice, Mr Gaoussou Touré; Minister of Higher Education and Scientific Research, Dr Abdallah A.T. Mabri and Professor Seraphin Kati-Coulibaly of the Université Félix Houphouët-Boigny and representative of the host country on the AfricaRice Board of Trustees.

United States Agency for International Development (USAID) is providing a 2-year funding support to the One Rice Breeding Program.

The Korean Rural Development Administration (RDA) has decided to continue funding the Africa Rice Development Partnership Program for a further 3 years (AfricaRice–KAFACI Phase II, 2020–2022). The aim is to consolidate the adaptation of the Korean Tongil varieties to African rice systems; successful results have already been delivered in Malawi and Senegal, through biotech breeding techniques. These varieties exhibit high yield potential and excellent grain quality.

An integrated rice–fish farming project is geared towards improving food security and nutrition in Liberia. This project is being funded by the European Union for a period of 3 years and is being implemented by AfricaRice (lead Center) and WorldFish, in collaboration with the Government of Liberia.

AfricaRice is working with partners in Senegal, including the private sector, to support the establishment of youth enterprises along the rice value chain. This project is funded by Mastercard Foundation for a period of 2.5 years. This project is complementary to a similar one on job and enterprise creation for youth through rice sector development in the Senegal River valley (dubbed the 'agCelerant™ Academy' project). The latter is being implemented in partnership with Manobi Africa, a company that delivers digital solutions and services. It is funded by GIZ for a period of one year, with possibilities for extension.

Intense advocacy carried out by AfricaRice to convey the desire of African countries to strengthen their rice value chains resulted in donor commitments, especially from the African Development Bank (AfDB) and the Islamic Development Bank (IsDB). Their commitment enables AfricaRice to provide support to the following countries in strengthening rice seed value chains: The Gambia, Guinea-Bissau, Niger and Sierra Leone.

One CGIAR transition and AfricaRice–IRRI programmatic alignment

AfricaRice fully supports the transformation of CGIAR into a more integrated 'One CGIAR' (www.cgiar.org/food-security-impact/one-cgiar/), with unified governance, an integrated operational structure, a new research modality, and more pooled funding. Such a transformation will enable the Center and its partners, especially the national agricultural research systems (NARS) in Africa, to achieve greater impact in the face of the interdependent challenges facing today's world. This will also contribute to better leveraging of resources, capabilities, presence, and partnerships, to advance rice science and the delivery of more appropriate rice technologies and innovations that will create more impact in Africa. This was demonstrated by the unanimous endorsement by the AfricaRice Council of Ministers (COM), in September 2020, of the resolution formulated by the National Experts Committee (NEC) for the adherence of AfricaRice to One CGIAR, and for the necessary amendments to be made to the Association's Constitution to comply with One CGIAR's governance framework.

Following the COM's endorsement, the Center has been actively involved in the implementation of the recommendations for the transition to One CGIAR, including the preparation of the One CGIAR 2030 Research and Innovation Strategy, the establishment of the Investment Prospectus for the delivery of the strategy, the design of the operational structure of One CGIAR, and the development and implementation of various transition plans.

Overtaken thus by the One CGIAR process, the AfricaRice–IRRI Institutional Alliance discussions were put on hold by the AfricaRice Board of Trustees pending the outcome of the CGIAR reform processes. The Board did, however, recommend that efforts continue toward programmatic alignment, as this strengthens the position of both AfricaRice and

IRRI within the context of the on-going One CGIAR process, to transform the rice sector in Africa.

To respond to this recommendation at a strategic level, AfricaRice initiated and has been leading the development of a new 5-year (2021–2025) Rice Research and Innovation Strategy for Africa. This robust new strategy focuses on enhancing profitable rice-based agri-food systems that respond to health and nutrition challenges as well as climate and environmental challenges in Africa and purports strong alignment with the One CGIAR 2030 Research and Innovation Strategy. It is meant to be presented to the COM for endorsement in 2021.

In sum, though 2020 was a very challenging year globally, it has also been a productive year for the Center and its partners. Many excellent results were delivered that will make a significant impact on the food security, nutrition and health, as well as the livelihoods of the African population. We express our sincere thanks to AfricaRice member states, donors, and development partners for their unwavering support. The AfricaRice Board of Trustees and Management would also like to thank all AfricaRice staff members for their commitment and dedication to the mission of AfricaRice, especially under the highly challenging circumstances of the COVID-19 pandemic.

Director General

Harold Roy-Macauley

Chair of the Board of Trustees

Carol Kramer-LeBlanc

Policy options to increase the resilience of domestic rice value chains during and after the COVID-19 pandemic

When the global financial crisis and subsequent rice price crisis hit West Africa in 2007–2008, a forearmed AfricaRice sprang into action with strong policy options to strengthen the region's rice sector and its resilience to future shocks. Ten years on, AfricaRice, Centre de coopération internationale en recherche agronomique pour le développement (CIRAD) and the International Rice Research Institute (IRRI) assessed West African governments' progress in upgrading the domestic rice value chain in 15 countries.[1]

Countries could be classified into three groups:

Group 1: high rice import bill, high paddy production, modernization of the rice value chain most advanced (Nigeria and Senegal);

Group 2: lower import bill and paddy production, moderate rice value chain upgrading, said to be "emerging" (Benin, Burkina Faso, Côte d'Ivoire, Ghana, Liberia, Mali, Niger, Sierra Leone and Togo);

Group 3: no evidence of value chain upgrading (The Gambia, Guinea, Guinea-Bissau and Mauritania).

While the data were being analyzed, the world was engulfed in the COVID-19 pandemic and governments' reactions to it, including closed borders and lockdowns. The impact on rice trade was straightforward: although, the world rice prices had been increasing just prior to the pandemic, they experienced a steep upward trend after the outbreak of

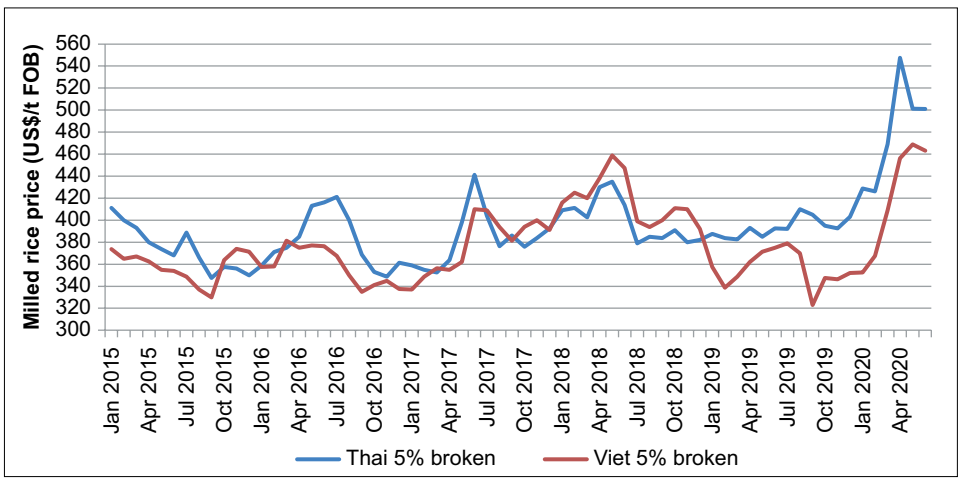

Figure 1. Evolution of international rice prices on the world market, January 2015 to June 2020

Notes: FOB, free on board. Thai and Viet refer to rice imports from Thailand and Vietnam, respectively.
Source: Arouna et al. (2020, data from OSIRIZ/InfoArroz, 2020).[2]

1. Value chain upgrading was assessed in relation to construction of modern milling facilities and contract farming. Soullier G, Demont M, Arouna A, Lançon F and Mendez del Villar P, 2020. The state of rice value chain upgrading in West Africa. *Global Food Security*, 25: art. 100365. https://doi.org/10.1016/j.gfs.2020.100365
2. Arouna A, Soullier G, Mendez del Villar P and Demont M, 2020. Policy options for mitigating impacts of COVID-19 on domestic rice value chains and food security in West Africa. *Global Food Security*, 26: art. 100405. https://doi.org/10.1016/j.gfs.2020.100405

COVID-19 in December 2019 (Fig. 1). Consequently, the research partners used the data to inform policy advice for governments to safeguard and build the resilience of rice value chains.

All countries were deemed at risk of regression of domestic rice value chain performance. The team provided short- and long-term recommendations for increasing value chain resilience, including:

- exempt mills from lockdown, while ensuring 'COVID safety' (e.g., masks, sanitization, social distancing);
- allow free movement of rice and inputs, including across borders;
- subsidize inputs (seed, fertilizer, pesticide) and ensure their timely availability to stimulate production;
- extend utility (electricity) bill payment deadlines for mills (or private sector in general);
- encourage local and foreign private investment in the value chain;
- continue (or increase) government and donor support for research and development.

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Rice is the most rapidly growing food commodity in sub-Saharan Africa (SSA) and boosting domestic supply is clearly important for the region.

Consortium of Rice Seed Enterprises and Millers

The role of quality seed in value chain upgrading and market access is clear. And AfricaRice has a long history of making farmers' access to quality seed easier, especially through its work on community-based seed systems and that with seed enterprises. However, for quality seed to really 'take off' there needs to be demand.

"There was a major gap in AfricaRice's dealings with seed stakeholders, namely millers," says AfricaRice Rice Sector Development Program leader Sidi Sanyang. Rice millers are often the link between the producers (farmers) and the market. If they show a marked preference for grain grown from quality seed, then farmers will start to demand quality seed.

The Consortium of Rice Seed Enterprises and Millers (COSEM-Riz) was established as a public–private partnership, facilitated by AfricaRice, with national partners (agricultural research institutes and seed regulatory agencies), seed enterprises and millers from West, Central and East Africa — to increase demand for quality rice seed of market-preferred varieties, and to produce foundation and certified seeds of the quality required by millers and consumers.

Some 79 enterprises and millers submitted 'expressions of interest', of which 40 later expressed an interest in joining the Consortium, including a commitment to its partnership guidelines.

Membership costs (needed to enable the public-sector partners to continue providing high-quality breeder seed and quality assurance) will likely be paid through one of three business models: fees, using a three-tier system; licensing and sublicensing (for hybrid varieties); and royalties. So far, 26 seed enterprises from 13 countries[3] have proposed membership fees they would be willing to pay.

Proprietors of the seed enterprises NAFASO of Burkina Faso (left) and FASO KABA of Mali (right), at a hybrid field day at M'bé for seed enterprises and millers

"The AfricaRice hybrid varieties are a major attraction," says Sanyang, "but so too is the toolkit designed to improve productivity and income, including RiceAdvice and GEM."

The enterprises fall into three groups: those with the capacity to produce both foundation and certified seed; those that can produce certified seed; and those that do not have the capacity to produce quality seed but can act as retailers.

"One of the enterprises is very keen: they have a former national plant breeder on board and are eager to take early generation (G2) breeder seed to multiply," says Sanyang. Most seed enterprises take later generation (G3) breeder seed to produce the foundation seed that is then grown on to produce certified seed for sale to farmers and projects.

"Overall, our goal is to make quality seed of inbred and hybrid varieties, along with the toolkit, available through the private sector in a sustainable and profitable way," concludes Sanyang.

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3. Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Ghana, Liberia, Madagascar, Mali, Niger, Nigeria, Senegal, Sierra Leone and Uganda.

Youth entrepreneurship and job creation in the rice value chain

Visit to young service provider Ndiaye Niasse (far left) at the CEMA of Pont Gendarme, Senegal

The 'Promoting Youth Entrepreneurship and Job Creation in West Africa's Rice Value Chain' (PEJERIZ) project, implemented in collaboration with the Technical Centre for Agricultural and Rural Co-operation (CTA) and the Syngenta Foundation for Sustainable Agriculture, in rural Mali and Senegal ended in 2020. Its two principal components were: capacity-building and awareness-raising regarding entrepreneurship opportunities in the rice value chain; and enterprise development, including links to financial support and markets.[4,5]

The project directly sensitized 310 young people on business opportunities in the rice value chain. Some 215 of these were then trained in entrepreneurship and technical skills, and information and communications technology (ICT) for agribusiness. Among these were 126 representatives of youth groups who reported back and passed on the training materials, reaching an additional 8666 youth.

An impact assessment conducted in May 2020 confirmed increased yields and increased income. Project beneficiary producers increased their rice area by an average of 0.9 ha and their yields by 1.96 tonnes/ha compared with non-beneficiaries; and achieved an average gross income from rice of €EU 456 per hectare in the dry season — the project helped them triple returns on their investments.

Overall, more than 2800 youths increased their incomes through the project. In terms of employment, each of the 78 enterprises established by beneficiaries of the project's competitive grants and finance through agricultural development banks created an average of over five jobs — that is 456 young people helped into employment by the project.

The 11 centers for mechanized services (CEMAs)[6] established by the project and promoted by Syngenta Foundation in Mali and Senegal achieved an estimated €144,360 gross income in the first year, providing mechanized services to 4278 farmers for 3385 ha of rice, RiceAdvice to 3757 farmers for 3439 ha, and advice on good agricultural practices to 10,139 farmers.

"The coaching and mentoring of the youth, in addition to the training, contributed to the success of the project," says AfricaRice agricultural economist and value chain specialist Mandiaye Diagne. "This support … made it possible to establish a relationship between the agricultural banks and the young agripreneurs who previously could not obtain loans from financial institutions. We are pleased that the project has had such a positive impact on so many young lives and wish them every success as fully independent agripreneurs."

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4. *See* 'Youth entrepreneurship and job creation in West Africa's rice value chain', *AfricaRice annual report 2018*, page 15.
5. *See* 'Getting young agricultural entrepreneurs on track in Mali and Senegal', *AfricaRice annual report 2019*, page 15.
6 The CEMAs employed youth as service providers for both mechanized services and digital services such as RiceAdvice (*see Annual report 2018*).

Women producing seed for women in Senegal

In the Fatick and Koalack regions of Senegal, women have typically grown rice in the lowlands. But these lowlands are becoming increasingly saline and the rice cultivars previously available were susceptible to salinity to the point that many of these farmers abandoned rice altogether. This is a problem because rice is a household staple. These lowlands also experience periodic drought and floods, and some have iron toxicity. In 2019, AfricaRice and its partners in the Nioro rice sector development hub helped some of these women identify four high-yielding salinity-tolerant rice varieties to revitalize their farming.[7]

In 2020, AfricaRice and the Agence Nationale de Conseil Agricole et Rural (ANCAR), a national extension organization of the Ministry of Agriculture in Senegal, conducted refresher training for 82 farmers (79 women) on quality seed production. Subsequently, a group of seed producers in Fatick Region produced 560 kg of certified seed on 2 ha of communal land under the supervision of the Seed Quality Control Unit of the Direction Régionale du Développement Rural de Fatick; AfricaRice provided the foundation seed and fertilizers. Despite the low yield, this was deemed a success in light of COVID-19 restrictions that precluded the anticipated close field supervision by the seed unit for this first-time venture.

"The plan is that the women will sell the certified seed to other members of their organization and other local farmers in time for the next season," says AfricaRice sociologist Maïmouna Ndour, "and the proceeds will be reinvested in the fledging seed business."

"We are encouraged by the success of the women seed producers in Fatick," says AfricaRice rice value chain expert and gender focal point Gaudiose Mujawamariya, "and by that of a similar group in Madagascar, where some women have produced over 800 kg of quality seed on just half a hectare of land."

The Fatick women seed producers

Supplying quality seed enables farmers to achieve good yields and increases the income of seed producers. The experiences in Senegal and Madagascar show the value of promoting seed production, especially among women.

An assessment of seed production as a business model showed that it can generate a net profit of US$ 950 per hectare per season. Women are therefore being encouraged to actively take up and own seed production — a business that is certainly rewarding when they have the skills, financial resources to cover the production costs, and a market.

"We are working with the group again in 2021," says Ndour, "when there will be additional training for these seed producers in entrepreneurship and marketing so that they can autonomously sustain the gains from seed productions."

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7. *See* 'Helping women feed their households in Nioro hub, Senegal', *AfricaRice annual report 2019*, page 16.

Release of high-yielding and early maturing varieties in Niger

While much of the world is looking at negative population growth within the next generation, Africa continues to experience the highest population growth rate among global regions. Combined with ongoing urbanization, the demand for rice also continues to increase unabated. Sub-Saharan Africa's rice imports (substantially more than 10 million tonnes a year for the past decade) are unsustainable for national economies.

"Increasing total production through widespread use of high-yielding and consumer-preferred varieties is one of the most sustainable and profitable options for farmers in sub-Saharan Africa," says AfricaRice regional representative in Senegal and irrigated rice breeder Baboucarr Manneh.

As a continental partnership, AfricaRice's primary mechanism for evaluating new varieties is the Africa-wide Rice Breeding Task Force,[8] which enables national programs to evaluate new germplasm from AfricaRice and other partner national programs alongside their own existing and upcoming varieties.

From this work, in 2020 the Institut national de recherches agronomiques du Niger (INRAN) released four new varieties for irrigated lowland production systems. Under the Economic Community of West African States (ECOWAS) variety release guidelines, these varieties are available to irrigated-rice farmers in all member states.

All four varieties have long and slender grains, which is the grain shape preferred by most rice consumers in sub-Saharan Africa. The four varieties have yield advantages over local variety Kogoni 91-1 of 12–22%. In addition, SEBERI 1, 2 and 3 are early maturing and well-suited to double-cropping and thus intensification of irrigated systems for increased annual production.

SEBERI 4 (originally HHZ5-SAL9-Y3-Y1) is salt tolerant, which is important as some irrigation schemes in the country have salinity problems. Both SEBERI 2 and SEBERI 3 are resistant to local (Nigerien) strains of blast disease, which sometimes inflicts serious yield losses on susceptible varieties such as Kogoni 91-1. In Niger, many farmers practice manual harvesting, for which taller plants are desirable — all four new varieties are taller than Kogoni 91-1. Other salient features of the varieties are given in Table 1.

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Table 1. Characteristics of four newly released irrigated rice varieties compared with popular local variety Kogoni 91-1, Niger, 2020

Name	Origin	Duration (days)	Plant height (cm)	Yield (t/ha)	Blast reaction*
SEBERI 1	Shuttle breeding (AfricaRice Bouaké, Cotonou and Ibadan; Togo)	100	107	6.7	S
SEBERI 2	Shuttle breeding (AfricaRice Cotonou; Togo)	115	110	7.2	R
SEBERI 3	Tanzania national program	110	115	6.8	R
SEBERI 4	China	126	118	7.3	S
Kogoni 91-1	Mali	130	95	6.0	S

* Reaction to local Nigerien strains of *Magnaporthe oryzae*: S, sensitive; R, resistant.

8. *See* 'The new Africa-wide Rice Breeding Task Force', *AfricaRice annual report 2011*, pages 7–11.

Maximizing the potential of African rice by creating a diversity panel

Domesticated in West Africa and with its center of diversity in Mali, *Oryza glaberrima* — African cultivated rice — is well adapted to low-input West African rice cultivation. The resistance of some landraces to local stresses — including *Rice yellow mottle virus*, bacterial leaf blight, African rice gall midge, iron toxicity and drought — means that *O. glaberrima* has long been mined for traits to be bred into modern varieties (typically Asian *O. sativa*).

Maximizing the use of conserved accessions of any crop depends on knowing what traits those accessions harbor. However, field-screening the entire AfricaRice collection of 3130 *O. glaberrima* accessions is impractical. Consequently, in 2017, AfricaRice and partners published core and mini-core sets representing 97–99% of the genetic diversity of 2179 accessions according to 27,560 single nucleotide polymorphisms (SNPs).

To revise these sets to cover the entire collection, all 3130 accessions were subjected to high-density genotyping against 49,685 SNPs at Diversity Arrays Technology (www.diversityarrays.com). AfricaRice then used the maximum length sub-tree method to select accessions preserving 97% of the collection's diversity.

"The mini-core set of 350 accessions includes those that have been screened and found resistant or tolerant to various traits," explains AfricaRice head of Genetic Resources Unit and genebank manager Marie-Noëlle Ndjiondjop. "Two-thirds of the mini-core set has still to be screened for traits including nutritional value."

Selected accessions are being multiplied to increase seed availability; they will then be screened and cataloged to become a source of local-adaptation traits for breeders in AfricaRice and beyond.

"There is more to *Oryza glaberrima* than breeding improved varieties," says Ndjiondjop. Some parts of West Africa (e.g., Guinea, Guinea-Bissau and Sierra Leone) only cultivate African rice landraces. Farmers' reasons for this are: (i) better adaptation to low-fertility, high-acidity soil; (ii) larger seeds, which germinate better and produce more vigorous seedlings; and (iii) good grain quality, better nutrition and digestibility. "*O. glaberrima* brown rice with a red pericarp is considered 'heavier' (i.e. digested more slowly) than white rice — a valuable characteristic for farmers, as a meal lasts them longer. Very colorful when you put it on your plate, this rice has a fantastic future in rice improvement."

Farmer in her field of Oryza glaberrima and okra, Danyi hill, Togo

These landraces are represented in the diversity panel of the mini-core set. It is likely that farmers would gladly adopt accessions that are better adapted to their needs.

"Landraces and knowledge about them are handed down from one generation to the next. By bringing samples into the genebank, along with the farmers' knowledge, we are preserving vital goods for posterity," says Ndjiondjop.

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Perennial rice

Growing annual rice is demanding on resources: labor (for land preparation and transplanting), water, increasing input costs. Moreover, even in Sahel irrigated systems where triple-cropping is theoretically feasible, the short time between seasons means that even double-cropping is extremely labor-intensive at peak times, and labor is no longer cheap. Resource-use efficiency is key for rice farmers in West Africa.

One of the African wild species closely related to cultivated rice is perennial *Oryza longistaminata*. Researchers at Yunnan University, China, have crossed *O. longistaminata* with *O. sativa* to develop perennial rice. AfricaRice is assessing the potential value of five perennial rice varieties in Côte d'Ivoire and Senegal, and the results from the first three growing seasons are looking promising.

Any rice crop can regrow 'ratoons' from the roots after harvesting. Perennial rice varieties can do this more substantially for many years.

"Perennial rice potentially has several advantages over normal, annual rice," says AfricaRice Agriculture and climate change specialist Elliott Dossou-Yovo, "among which we count reduced labor, increased resource-use efficiency and reduced soil disturbance leading to better soil carbon storage."

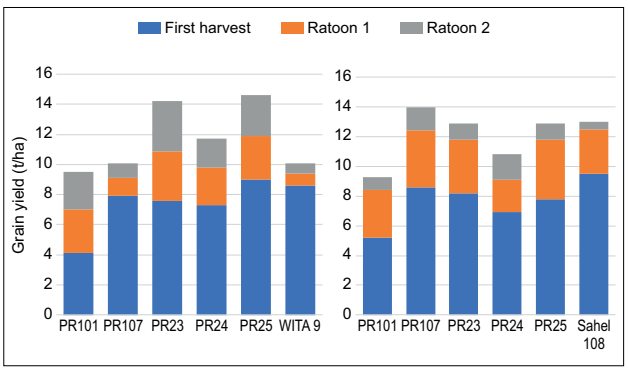

Figure 2. Performance of five perennial rice varieties against local checks in M'bé/Bouaké (Sudan savannah with bimodal rainfall, left) and Ndiaye/Saint-Louis (Sahel with monomodal rainfall, right)

"However, perennial rice needs to be competitive for the farmers in terms of production, grain quality, and disease and pest resistance," says AfricaRice Agro-physiologist Nouhoun Belko.

Perennial rice varieties typically produced less grain than the local checks (WITA 9 in Côte d'Ivoire and Sahel 108 in Senegal) at the first harvest, but two subsequent harvests in the same year from the regrowth ratoons resulted in some varieties outyielding the local check, especially in the bimodal Sudan savannah at M'bé, Côte d'Ivoire (see Fig. 2).

But it is no longer just about grain yield in the search for new agricultural technologies. The perennial varieties are also being assessed for consumer-preferred traits, resistance to rice diseases and pests, and grain quality.

"One of the varieties (PR 107) has long grains and is aromatic — popular traits among consumers and farmers alike in parts of the region," says AfricaRice System agronomist Ibrahim Ali. "Moreover, two (PR 23 and PR 25) that have good agronomic characters showed resistance to the important rice diseases bacterial leaf blight and *Rice yellow mottle virus*." Meanwhile, grain quality analyses are ongoing in the laboratory.

"An important question we have to answer is whether grain quality will be preserved across harvests," says Belko. "In truth, if it is not, then perennial rice simply isn't going to work here."

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Expanding irrigated rice cultivation with water-saving technology

A principal goal of the majority of West African countries' agricultural policies is rice self-sufficiency. Irrigated agro-ecosystems hold the most promise in terms of productivity and the ability to manage floods and droughts that are increasing under climate change and can be devastating for rainfed systems. Increasing domestic production to the point of self-sufficiency implies area expansion, as current yield levels are insufficient on the land currently cultivated. For expansion of irrigated rice, a major constraint is water scarcity.

'Alternate wetting and drying' (AWD) emerged from work to test the System of Rice Intensification (SRI). AWD is proven to decrease water need compared with traditional production in (flooded/ponded) paddies, but the effects on rice yields have been inconsistent. Refinement of AWD in experiments and practice over time has led to the development of 'safe AWD', in which the rice field is flooded for 10–14 days immediately after transplanting and again from heading to the end of flowering, with AWD during all other periods (see Fig. 3a).

During the AWD periods, when the groundwater level drops below 15 cm below the soil surface, the field is irrigated. The farmer checks the groundwater level daily by means of a field water tube (Fig. 3b), which is placed in a hole in the ground.

Safe AWD reduced water use by 30%, weeds by 36% and greenhouse gas emissions (methane) by 50% compared with traditional production, while not compromising grain yield. As a result of reduced weed pressure, AWD also reduces overall labor requirement.

In essence, the initial flooding suppresses weed germination, the AWD constrains the growth of water-loving weeds and reduces water use, and the second flooding enhances nutrient-use efficiency of fertilizer applied at panicle initiation — these combine to provide the positive impacts of 'safe AWD'.

The question for rice development is: where can rice area be expanded into water-constrained areas where safe AWD could enable production at or above the levels achieved by traditional irrigated rice production?

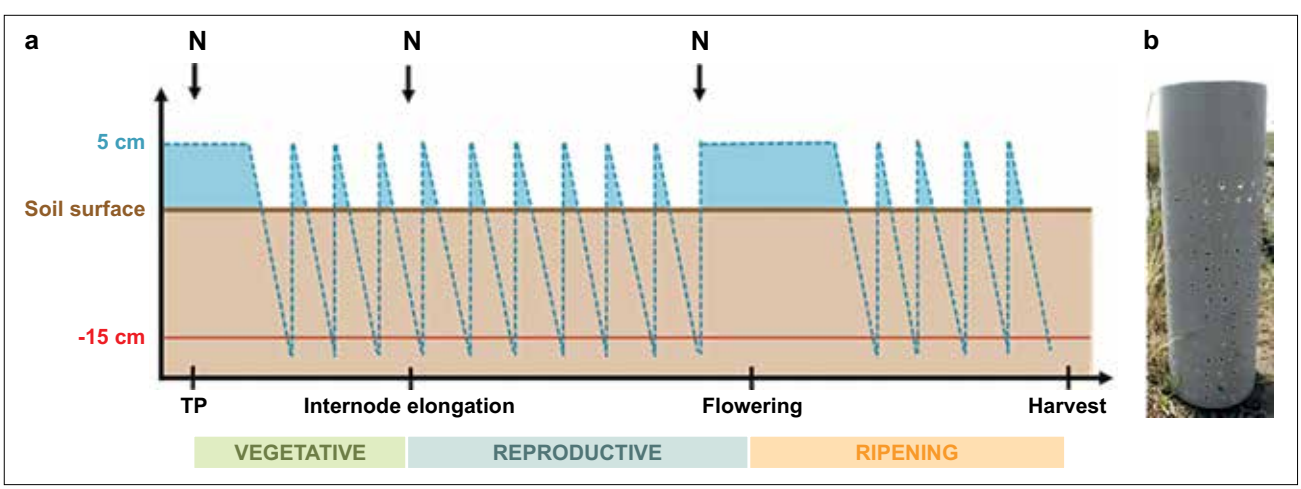

Figure 3. (a) 'Safe' alternate wetting and drying (AWD), and (b) simple field water tube for groundwater monitoring

Note: The arrows indicate the timing of nitrogen fertilizer application; blue shading, irrigation water; dashed blue line, field water level; TP, transplanting.

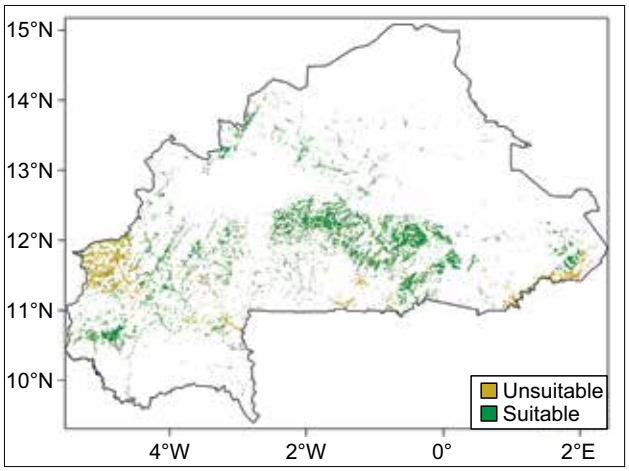

Figure 4. Map of schemes suitable for AWD scaling in Burkina Faso for the period 1 August to 10 September

Note: The suitability for AWD presented here is based on soil percolation values in the water-balance model.

A team from the Regional Center for Energy and Environmental Sustainability (RCEES) of the University of Energy and Natural Resources (UENR, Ghana), AfricaRice and the International Water Management Institute (IWMI, Ghana) investigated this question for Burkina Faso as a case study.[9]

The team developed and implemented a two-step, spatially explicit approach. Machine learning models Random Forest and Maximum Entropy were used to determine land suitability for irrigated rice cultivation. Then climatic suitability for AWD was determined using a water-balance model for the two main growing seasons (February–June and July–November) on a 10-day timescale (decad). The data used to calibrate and validate the models, and to determine the areas suitable for safe AWD, were all from previously published sources.

Some field observations showed that irrigated rice performs better on soils with higher pH (less acidic); current nitrogen fertilizer levels are too low for targeted yield levels, while improved nitrogen-use efficiency should encourage investment in N fertilizer to increase yield; and "better congruence between nitrogen fertilizer application and crop N demand", in particular simultaneously flooding and applying N fertilizer around panicle initiation, increases nutrient-use efficiency compared with applying fertilizer 7–10 days before flooding.[10]

The study determined that 2.1 million hectares of land in Burkina Faso are suitable for irrigated rice under 'safe AWD'. The whole dry season is suitable for AWD, but suitability of the wet season is 25–100% depending on the soil percolation status.

Although currently only theoretical (because use of the data to guide rice development is still to occur), "these results show what is possible with modeling," says AfricaRice agriculture and climate change specialist Elliott Dossou-Yovo. "We have mapped areas that can be brought under irrigated rice cultivation with 'safe AWD' (*see* Fig. 4). The framework developed in this study can be applied to other West African countries to guide investment in irrigated rice expansion and AWD scaling for water-saving, greenhouse gas mitigation and ecosystem services preservation."

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9. Akpoti K, Dossou-Yovo ER, Zwart SJ and Kiepe P. 2021. The potential for expansion of irrigated rice under alternate wetting and drying in Burkina Faso. *Agricultural Water Management*, 247: art. 106758. https://doi.org/10.1016/j.agwat.2021.106758

10. Dossou-Yovo ER and Saito K. 2021. Impact of management practices on weed infestation, water productivity, rice yield and grain quality in irrigated systems in Côte d'Ivoire. *Field Crops Research*, 270, art. 108209. https://doi.org/10.1016/j.fcr.2021.108209

Fertilizer from waste — saving the environment and money

Irrigated rice farming is typically more productive, and therefore more profitable, than rainfed rice. A major expense for irrigated-rice farmers is fertilizer, so any means of reducing this cost is welcome. One route is to tailor fertilizer recommendations to the specific rice field and yield target (e.g. RiceAdvice), another is to find alternative, cheaper fertilizers.

Ajinomoto Co., Inc. is a Japanese food and chemical company working in 30 countries and territories globally. A by-product of the production in Côte d'Ivoire is a natural 'waste' that has good levels of nitrogen (14% N), potassium (6% K_2O), sulfur (20% S) and sodium (6% Na_2O). With funding from the Japanese Ministry of Agriculture, Forestry and Fisheries, AfricaRice is testing use of the by-product as a substitute for N and compound fertilizers in Côte d'Ivoire.

"The original idea was to see whether Ajinomoto by-product could substitute urea as N fertilizer, while retaining the extension-recommended compound fertilizer," says Koichi Futakuchi, Sustainable Productivity Enhancement Program leader. "However, in the phosphate-rich soils at Gagnoa and Korhogo, the product also substituted compound fertilizer well."

"After preliminary trials at M'bé and Gagnoa, we tested three high-value aromatic varieties under three fertilizer regimes at three sites representing the key irrigated agro-ecosystems of the country," says AfricaRice Agro-physiologist Nouhoun Belko. These trials were placed beside farmers' fields and followed farmers' practices for weeding, fertilizer application method and irrigation.

The first-year results have been impressive: rice fertilized with the Ajinomoto by-product in some cases yielded as well as or better than that receiving full extension-recommended doses of compound fertilizer and urea (*see* Fig. 5). These results are being confirmed in the three locations in 2021 through on-farm trials in both wet and dry seasons.

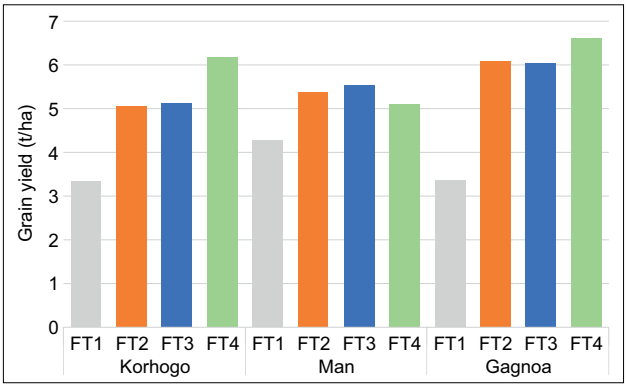

Figure 5. Grain yield of aromatic variety JT-11 in 2020 at Korhogo (Sudan savannah, monomodal rainfall), Man (forest, monomodal rainfall) and Gagnoa (forest, bimodal rainfall)

FT1, no fertilizer; FT2, extension-recommended inorganic fertilizer; FT3, urea replaced with Ajinomoto by-product; FT4, both urea and compound fertilizer replaced with Ajinomoto by-product.

If the results hold true, "we will set up demonstration plots at the three sites, involving 30–50 farmers at each," says Belko. Ten percent of the participating farmers at each site will be women — slightly higher than women farmers' participation in general in irrigated rice in the country. The demonstrations will grow the rice variety that best responds to the Ajinomoto fertilizer at each site. A socio-economic analysis will be included to verify the viability of the practice. "If this all proves successful, we aim to promote the use of 'Ajinomoto fertilizer' to irrigated rice systems throughout West Africa," explains Belko. At the very least, this should reduce production costs and increase farmers' profits.

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RiceAdvice generates additional production worth millions of dollars in Nigeria

Working with a rice farmer to input data to generate RiceAdvice recommendations

Shortly after the introduction of RiceAdvice to Kano State, Nigeria in 2016,[11] AfricaRice conducted an impact assessment to provide evidence of the value of the app to the rest of the country and similar rice-growing conditions in other West African countries;[12] and brought together rice stakeholders to diagnose the bottleneck for scaling.[13]

Seven hundred households in 35 villages were surveyed three times in 2016–2017 using an experimental impact assessment method (randomized control trial, RCT). Farmers who received only RiceAdvice recommendations increased their yields by 7% over the control (250 kg/ha), which translated into a 10% increase in profit (US$ 120 per hectare), while those who received the RiceAdvice recommendations and the recommended fertilizers increased their yields by 20% (730 kg/ha) and their profit by 23% ($275/ha).

Thus, although RiceAdvice recommendations alone have positive impact, improved access to inputs helps increase the impact. An estimated 8115 farmers benefited from RiceAdvice in 2016 and generated additional production of 7625 tonnes, worth $3.7 million. Calculations based on an average treatment effect suggest that universal adoption of personalized advice by all 124,000 rice farmers in Kano State would result in a net gain of $59 million.

Qualitative and quantitative data were also collected through semi-structured interviews, multistakeholder workshop, and structured interviews. In line with earlier findings, most farmers who received and applied RiceAdvice recommendations noted a decrease in compound fertilizer use and an increase in yield, both by more than 25%. This increased income by more than 25%, and there were other livelihood improvements via human, social and physical capital.

Personalized advice using the app increases yield without increasing the overall quantity of fertilizer. The scaling of the app could improve productivity and livelihoods in sub-Saharan Africa while reducing the environmental chemical footprint. However, for further scaling of RiceAdvice, the research recommends: (i) increasing farmers' access to financial and input supply services; (ii) designing and implementing business models where RiceAdvice can be used; and (iii) including female service providers to reach female farmers.

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11. *See* 'Wide-scale deployment of RiceAdvice in Mali and Nigeria', *AfricaRice annual report 2016*, pages 17–18.
12. Arouna A, Michler JD, Yergo WG and Saito K. 2020. One size fits all? Experimental evidence on the digital delivery of personalized extension advice in Nigeria. *American Journal of Agricultural Economics*, 103(2): 596–619. https://doi.org/10.1111/ajae.12151
13. Zossou E, Saito K, Assouma-Imorou A, Ahouanton K and Tarfa DB. 2020. Participatory diagnostic for scaling a decision support tool for rice crop management in northern Nigeria. *Development in Practice*, 31(1): 11–26. https://doi.org/10.1080/09614524.2020.1770699

Excellence in Agronomy 2030: focus on agronomic gain, sustainable intensification, and scale

In response to growing demand from both public and private sectors for scalable agronomic innovations as an engine for sustainable agricultural development, 10 CGIAR Centers[14] launched the Excellence in Agronomy 2030 (EiA 2030) initiative on 7 September, during the African Green Revolution Forum virtual summit 2020.

"Smallholder (and other) farmers are interested in more than just yield: they are concerned about profit, risk and labor — among other things," says AfricaRice Agronomist Kazuki Saito. "Breeders have produced many varieties that have the potential to far exceed the low yields that most rice farmers in Africa achieve — unlocking that potential requires agronomy."

The keys to EiA 2030 are agronomic gain,[15] sustainable intensification, and scale; and it will operate around five key elements.

- *Towards increased efficiencies:* A global agronomy research and development (R&D) network to facilitate exchange of learning, tools and assets between regional programs to create efficiencies in R&D workflows. AfricaRice is leading the development of the agronomic gain framework.
- *Alignment of R&D to demand:* An R&D portfolio based on demand from credible scaling/demand partners, and development, validation and scaling processes facilitated through co-creation with such partners. AfricaRice is involved in two 'use cases': digitizing fertilizer and agronomic advice in Nigeria for Sasakawa Africa Association, led by the International Institute of Tropical Agriculture (IITA); and leading digital advisory services in maize- and rice-based cropping systems that use a new 30-meter resolution soil map of Africa,[16] to which AfricaRice contributed.
- *Standardization of data processes and tools:* Infrastructure to collect and host data and tools following agreed standards and governance principles.
- *Integration of technological advances:* Integration of technological innovations as a standard practice for all EiA 2030 work — for predictive agronomy at scale.
- *Process innovation:* A solution development–validation–scaling pipeline, supported by clear 'go/no-go' decision-making processes and internal milestones.

The first two years of EiA 2030 will be an 'incubation phase' funded by the Bill & Melinda Gates Foundation. Meanwhile, proposal writing is underway to make EiA 2030 a 'large project' under the 'One CGIAR'.

The Incubation Phase is piloting activities to validate key hypotheses around the potential value added through (i) enhanced cooperation and cross-learning among CGIAR Centers, (ii) positioning agronomy R&D in direct response to demonstrated demand from active scaling partners, and (iii) integrating data and digital tools to support the development of agronomy

14. AfricaRice, CIAT, CIMMYT, CIP, ICARDA, ICRISAT, IFPRI, IITA, IRRI and World Agroforestry (for abbreviations see inside back cover).
15. Saito K, Six J, Komatsu S, Snapp S, Rosenstock T, Arouna A, Cole S, Taulya G and Vanlauwe B. 2021. Agronomic gain: Definition, approach, and application. *Field Crops Research*, 270: art. 108193. https://doi.org/10.1016/j.fcr.2021.108193
16. Hengl T, Miller MAE, Križan J, Shepherd KD, Sila A, Kilibarda M, Antonijević O, Glušica L, Dobermann A, Haefele SM, McGrath SP, Acquah GE, Collinson J, Parente L, Sheykhmousa M, Saito K, Johnson JM, Chamberlin J, Silatsa FBT, Yemefack M, MacMillan RA, Wendt J, MacMillan RA, Wheeler I and Crouch J. 2021. African soil properties and nutrients mapped at 30 m spatial resolution using two-scale ensemble machine learning. *Scientific Reports*, 11: art. 6130. https://doi.org/10.1038/s41598-021-85639-y

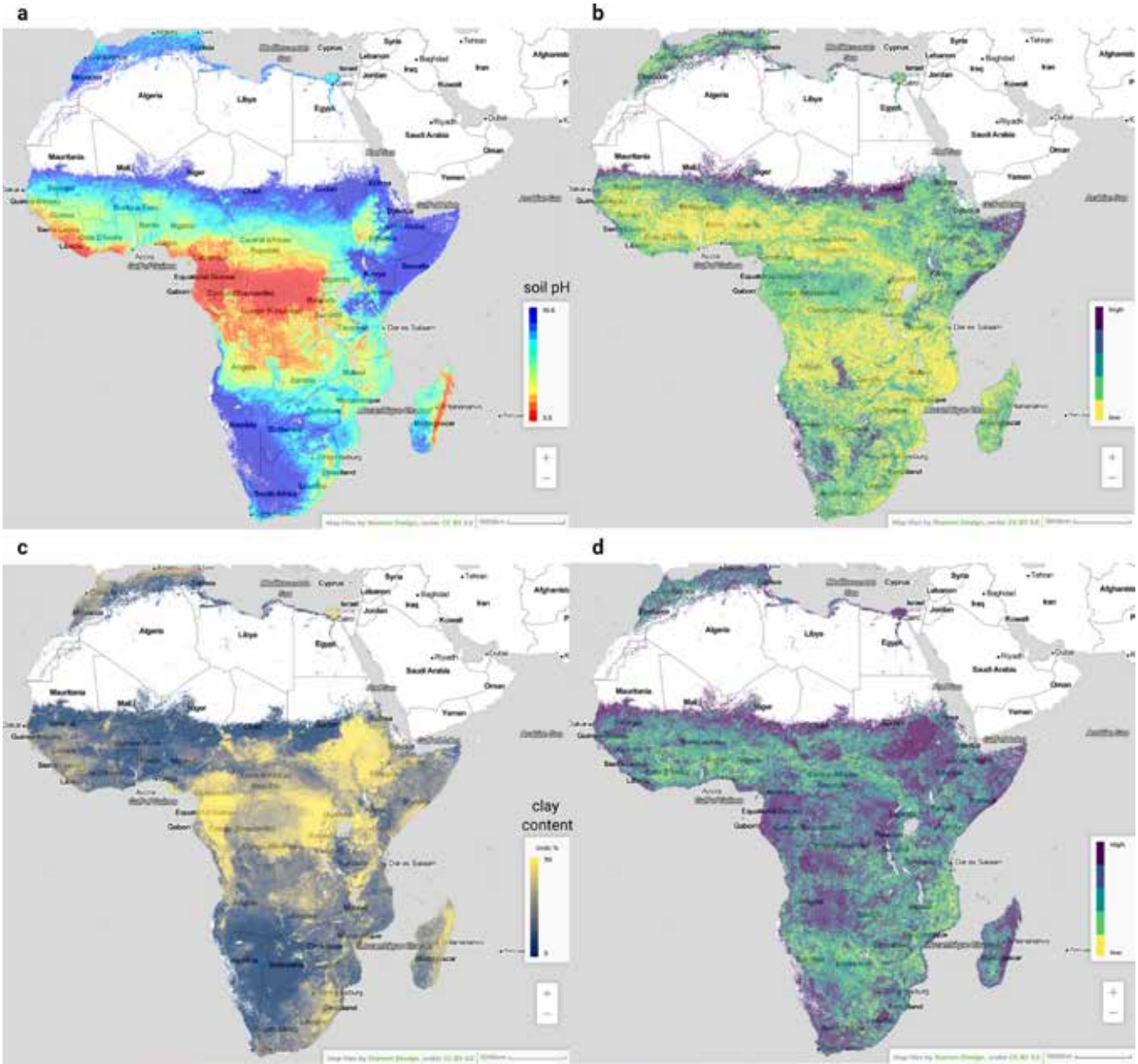

Figure 6. Predictions (left) and prediction uncertainty expressed as 1 standard deviation prediction error (right), for soil pH (a,b) and clay content (c,d) for the 0–20 cm depth interval. Visualized in the iSDAsoil app: https://isda-africa.com/isdasoil (Hengl et al., 2021; Creative Commons Attribution 4.0 International License)

solutions at scale. 'Success' is defined as: (i) having the key building blocks for EiA 2030 set up and used effectively across CGIAR Centers; (ii) increased demand from scaling partners for agronomic solutions; and (iii) all 10 participating Centers having contributed to EiA 2030 development.

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Low-glycemic rice

The demand for low-glycemic starchy staples is increasing. This is because diabetes is on the rise globally and food with lower glycemic index (GI) results in less glucose in the blood than food with higher GI.

It is well known in nutrition circles that rice has a substantially lower GI than white (wheat) bread (the reference food, GI = 100), and that GI differs according to both variety and processing. In particular, high-amylose varieties tend to have higher GI and parboiling reduces GI — the latter demonstrated in rats.

To determine the effect of pre-cooking rice processing on *human* GI, two varieties were subjected to six kinds of processing, eaten and the test subjects' blood glucose levels monitored for 2 hours.[17] Across varieties, rice that had been parboiled as paddy then polished (i.e. no husk, no seed coat) had the lowest GI (< 27); paddy-parboiled unpolished, brown-parboiled unpolished and brown-parboiled polished rice had similar 'intermediate' GI levels (27–39); and polished and unpolished un-parboiled rice had highest GIs (≥ 39) (Fig. 7). Thus, in terms of processing, paddy-parboiled polished rice is best for diabetics.

"What we are seeing here are the two main effects of processing," says AfricaRice grain quality and postharvest technology scientist Sali Ndindeng. "Parboiling does two things: it forces micronutrients from the husk and the bran layer into the grain, which is why it is popular as a nutritional step, but it also makes some of the grain starch (carbohydrate) resistant to digestion so that it contributes less to increase in blood sugar. Subsequently, polishing removes the seed coat with its proteins, which consequently also slows digestion."

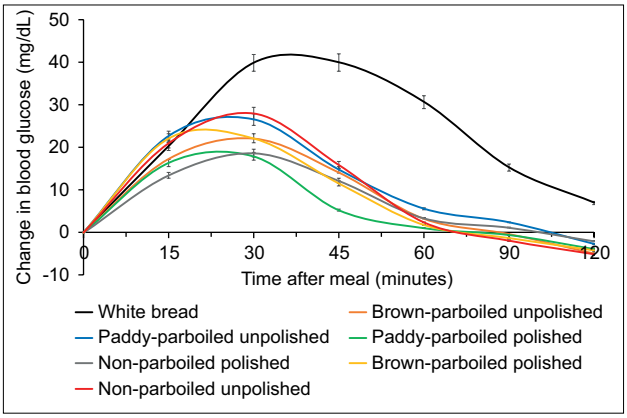

Figure 7. Blood glucose levels after eating rice subjected to different pre-cooking processing methods

Note: Glycemic Index (GI) = $\frac{\text{Area under the curve (test)}}{\text{Area under the curve (white bread)}} \times 100.$

Among 23 varieties, even the highest GI recorded after parboiling (55 for IR 55411-53) was within the official nutritional range of "low GI"; however, seven had very low human GI (< 26), including the already well-accepted ORYLUX 6 (GI = 22.3). In general, low-amylose and low-protein varieties (which are typically yellow after parboiling) had lowest GIs (although high-amylose TOG 6813 is an exception with a GI of 20.4).

"The genotypes identified as low GI can be promoted as a component of improved parboiling technology when the goal is to produce low-GI rice for the market," says Ndindeng. "We conducted some promotional work in Abidjan in 2020 with Riz National (RINA SARL) de Côte d'Ivoire marketing one product. This work will be expanded in 2021."

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17. The GI of a food is the amount of carbohydrate (starch) digested (and therefore transferred into the bloodstream) in the first 2 hours after consumption as a percentage of that of white bread.

Improved and nutritious red rice for Madagascar

A long time ago, people in Madagascar ate red rice. Then, at the end of the nineteenth century, when the country was colonized, the local red rice became marginalized by the newcomers' preferred white rice.

For decades, red rice was confined to small plots on farms for home consumption. Farmers prefer it for its slower digestion (keeping them 'full' for longer) and as a base for weaning their children (first as a rice soup and then as a porridge). Traditional early morning breakfast (*vary amin 'ny anana*) comprises soft red rice, vegetables and meat to set farmers up for a day of hard work. Dinner is a kind of red rice porridge, called *vary sosoa*. But the popularity of red rice is on the rise in Madagascar for its nutritional value, including among urban consumers.

This is a "comeback of the traditional asset as a nutritious alternative, fetching high interest and price," says AfricaRice high-altitude rice breeder Negussie Zenna. "We are helping farmers to gain from this opportunity by providing an even better version of red rice that would change their livelihoods and also provide the market with the new alternative."

Farmers in the rice sector development hub of Ambohibary prefer to grow red rice as a speciality crop, including for export. However, Malagasy red rice landraces are low-yielding, sensitive to cold and have long growth duration.

AfricaRice obtained early breeding lines from the Temperate Rice Research Consortium. These are *japonica* types that become soft and sticky on cooking — traits preferred by Malagasies. AfricaRice and Centre National de Recherche Appliquée au Développement Rural (FOFIFA) screened the breeding lines and then conducted participatory varietal selection with traditional red-rice-growing farmers.

As a result, three new red rice varieties are in the pipeline for release. They combine early maturity, high yield, high protein content, high milling recovery and cold tolerance, making them ideal candidates to compete with white rice on the market. All three have low amylose content and good taste similar to the local landraces.

"In a new project funded by the European Commission, we are expanding the new red rices within Madagascar and in neighboring Comoros, and training farmers to produce quality seed, because seed availability is often a bottleneck for quick and wide adoption of new varieties," says Zenna.

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Participatory varietal selection of red rice, Ambohibary

Red rice for sale in a Malagasy market

The AfricaRice management is pleased to report the improving financial situation of AfricaRice during the year ended 31 December 2020. The following are the highlights of the financial results:

Financial situation

The total operating revenues of the Center decreased from US$ 17.005 million in 2019 to US$ 12.142 million in 2020, corresponding to a decrease of US$ 4.863 million. The operating expenses also decreased from US$ 16.884 million in 2019 down to US$ 13.161 million in 2020, corresponding to a decrease of US$ 3.723 million. This resulted in AfricaRice recording an operational deficit of US$ 1.019 million in 2020 against the operational surplus of US$ 0.121 million in 2019. Additionally, the net non-operating financial expenses decreased the annual deficit for the year to US$ 1.013 million compared to the surplus of US$ 0.083 million recorded at the end of 2019. The undesignated net assets of the Center decreased from US$ 3.326 million at end of 2019 to US$ 2.662 million at the end of 2020.

Other indicators of financial health

The short-term solvency (liquidity) indicator level of the Center was improved to 111 days, up from 96 days as indicated for 2019, and the long-term financial stability ratio was similarly improved to 79 days up from 73 days as indicated for 2019. The audited indirect cost rate for AfricaRice increased to 20.9% during the year, from 14.3% in 2019, as indicated. The current ratio reduced from 1.33 in 2019 to 1.19 in 2020, which is within the CGIAR recommended level (greater than 1.0).

Summary Financials (expressed in thousands of US$)

	2020	2019
Income statement		
Revenues	12,142	17,005
Operating surplus/(deficit)	(1,019)	121
Surplus/(deficit) for the year	(1,013)	83
Balance sheet		
Fixed assets (NBV)	2,966	3,164
Working capital	3,726	4,378
Non-current liabilities	2,366	2,202
Net assets		
Undesignated	2,662	3,326
Designated	1,664	2,014

Statements of activity (expressed in thousands of US$)

	Total 2020	Total 2019
Revenue and gains		
Grant revenue		
Windows 1 and 2	2,916	4,177
Window 3	5,766	4,573
Bilateral	3,367	7,676
Total grant revenue	**12,049**	**16,427**
Other revenue and gains	93	578
Total revenue and gains	**12,142**	**17,005**
Expenses and losses		
Research expenses	9,669	11,756
CGIAR collaboration expenses	-	-
Non-CGIAR collaboration expenses	1,221	3,018
General and administration expenses	2,272	2,110
Other expenses and losses	-	-
Total expenses and losses	**13,161**	**16,884**
Operating surplus/deficit	(1,019)	121
Gain/loss on sale of assets	2	33
Restructuring cost/others	-	-
Financial income	6	-
Financial expenses	(2)	(72)
Surplus/(Deficit) for the year	**(1,013)**	**83**

List of donors

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AfricaRice training program (courses)

48 Training courses run in 2020

26 Locations in **8** countries

2,154 Total trainees

... of whom

462 Female

1,692 Male

Postgraduate trainees

15 Total female postgrads

27 Total male postgrads

26 PhD students

... of whom

9 Female

17 Male

16 MSc students

... of whom

6 Female

10 Male

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Abbreviations

ANCAR	Agence Nationale de Conseil Agricole et Rural (Senegal)
AWD	Alternate wetting and drying
CARD	Coalition for African Rice Development
CARI	Central Agricultural Research Institute (Liberia)
CEMA	Center for mechanized services
COM	AfricaRice Council of Ministers
COVID-19	coronavirus disease 2019
CORIS	COVID-19 Response Rice Seed
COSEM-Riz	Consortium of Rice Seed Enterprises and Millers
EiA 2030	Excellence in Agronomy 2030
EiB	Excellence in Breeding
FOFIFA	Centre National de Recherche Appliquée au Développement Rural (Madagascar)
ha	hectare
INRAN	Institut national de recherches agronomiques du Niger
ISBN	International Standard Book Number
KAFACI	Korea–Africa Food and Agriculture Cooperation Initiative
MAFF	Ministry of Agriculture, Forestry and Fisheries (Japan)
MOF	Ministry of Finance (Japan)
MOFA	Ministry of Foreign Affairs of Japan
NBV	net book value
NEC	AfricaRice National Experts Committee
pp.	pages
SNP	single-nucleotide polymorphism
SRI	System of Rice Intensification
t	tonne(s)

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