More effective targeting of research for development

Africa Rice Center (AfricaRice) – Annual Report 2017

AfricaRice

CGIAR

Cover: AfricaRice is targeting its research to the needs of rice stakeholders. For example, the development of high-value varieties, such as Orylux 6 (shown here), is greatly appreciated by Mr Ali Hema (inset), a veteran rice farmer in M'be 1, Bouaké, Côte d'Ivoire.

Contents

AfricaRice

Message from the Board Chair and Director General

A key approach of AfricaRice in contributing to providing enough food for the continent's growing populations is supporting efforts of African countries to achieve self-sufficiency in rice. With continuous increase observed in population growth rate and resulting higher rice consumption rate over production rate, AfricaRice is focussing on improving the access to rice technologies and innovations. There is an urgent need, however, to accelerate the process. Consequently, AfricaRice is seeking to more effectively target its research to the needs of rice stakeholders. This year's report highlights research and innovation activities and resulting achievements that are underpinned by the notion of targeting.

Research and innovation highlights

The characterization of the Center's collection of African rice (*Oryza glaberrima*) germplasm, resulting in the development of a mini-core collection, will maximize the utility and use of the variation contained in this germplasm. This tool will allow rice breeders across the continent and beyond, easier access to valuable genes held in African rice for introgression into new varieties, which will be better suited to the environment and consumer preferences, than existing ones.

New lowland varieties for both rain-fed and irrigated ecosystems and new maps to aid targeting of abiotic-

Chair of the Board of Trustees, Prof. Em. Dr Ir. Eric Tollens (right), with Director General, Dr Harold Roy-Macauley

stress-tolerant varieties and related breeding efforts, have been released across the continent over the past few years. They aim at enabling rice farmers to improve the quality and yield of their grain in the face of numerous stresses.

A new partnership agreement with the Republic of Korea has resulted in bringing Korea's unique 'Tongil' rice varieties into play in Africa on a wide scale. This is an illustration of AfricaRice continued engagement in leveraging partnerships in all spheres of its work to contribute to breeding useful varieties.

The introduction, testing and dissemination of baskets of targeted 'good agronomic practices' (GAP baskets), have included land-preparation options, variety choice, crop establishment, weed management and nutrient management. Success is attributed to the overarching aim of the Africa-wide Rice Agronomy Task Force, coordinated by AfricaRice in partnership with national program agronomists, which is to sustainably improve rice production and productivity. Some of the outputs and the plans for scaling up components of GAP baskets are reported.

The Ankazomiriotra innovation platform, a major component of the rice sector development hubs in Madagascar, is one of AfricaRice's tried-and-tested mechanisms for increasing the performance of rice value chains. This platform is still growing, after 2.5 years of existence, and assuring the production of quality seed of varieties such as NERICA 4 for local and international use, constructing infrastructure to upgrade the value chain, and seeing increasingly strong linkages forged between the various actors in the value chain.

The use of improved, modern practices in harvesting and processing rice could result in as much gain in milled rice as the use of new rice varieties with 'traditional' harvest and postharvest practices. This suggests that investment in harvesting and postharvest practices and technologies should at least match that in varietal development.

Our study on the high value that consumers in Dakar place on aromatic rice brands and varieties confirmed their increasing popularity in West Africa in recent years. The research further suggests that advertising and branding could be a key to promoting local aromatic rice.

The revelation, from an impact study, of where exactly along the rice value chain the adoption of new improved varieties is having a positive impact demonstrates the importance of targeting of research and technologies. The study highlights the benefits of contractual arrangements between processors and producers to ensure the use of quality seed and best farming and postharvest practices, which could be integrated into a business model for rice farming.

AfricaRice strongly believes that big data in agriculture are 'global public goods' just like the products delivered through our research. We demonstrate this by providing an update on activities that aim to render our datasets open access in the context of the CGIAR Platform for Big Data in Agriculture.

Gender research has been a vital component of the CGIAR agenda for over 30 years, and AfricaRice is building up its capacity in this vital area to improve targeting of its technologies and services to all value-chain actors.

Talking of capacity-building, four of the PhD students who successfully defended their theses this year have also received awards for various aspects of their work. This reflects the quality of the supervision provided by the Center, and the award-winning research feeds directly into research-for-development targeting.

Slow and steady expansion of the Association

AfricaRice is unique among the CGIAR Centers in that it is an association of Member States. The Republics of Mozambique and Kenya submitted requests for adhesion to AfricaRice in 2017 and 2018 respectively.

Mozambique's request has been duly accepted and will be endorsed as the 27th member country of AfricaRice during the Council of Ministers (CoM) meeting scheduled for September 2018. In the case of Kenya, a decision will be taken during the COM and Kenya is lined up to be the 28th member country.

Relocation and streamlining

The Center embarked on streamlining its workforce and facilities in 2017. In particular, new and rehabilitated facilities in the areas of biotechnology, grain quality and genetic resources (genebank and seed unit) came online at the main research station in M'bé. By the end of 2017, more than half of AfricaRice's 203 staff were stationed in Côte d'Ivoire, with 63 of them at M'bé. Though AfricaRice relentlessly pursues research and development activities with partner institutions in East and Southern Africa, office activities in the East and Southern Africa Regional Office in Dar es Salaam, Tanzania, were suspended and the majority of senior staff was relocated to the Madagascar Country Office.

Financial situation

In order to recover from three consecutive years of budget deficit from 2015 to 2017, resulting from continued reduction in CGIAR funding, huge relocation costs and the writing-off of bad debts, the Center established a 3-year financial recovery plan (2018–2020) aimed at achieving annual revenue of US$ 25 million and reserve days over the CGIAR threshold level by 2020. These include streamlining measures to reduce operational costs and efforts to maintain a relatively appreciable restricted revenue level through bilateral funding. The Centre is considered a going concern and it has continued to adequately deliver on its mandate. Intense advocacy was also established to increase Member States' payments of annual dues and arears, which unfortunately has had very little effect.

Support to CGIAR System Organization activities

The Board Chair and Director General continued to be active participants in the activities of the CGIAR System Organization, mainly through email exchanges, conference calls, participation in the inaugural General Assembly of Centers, and strategic visits to partner institutions — as one of six delegates to visit the new President of the International Fund for Agricultural Development (IFAD). In these ways, AfricaRice was able to contribute to the various issues addressed by CGIAR, including CGIAR image, resource mobilization and finance, governance, and partnership frameworks.

Looking forward

While continued investments by countries have led to improvements in their rice sectors, there is an urgent need to accelerate the process if Africa is to reach its target dates of attaining rice self-sufficiency. Three key actions initiated for this are considered to be promising:

Continental Investment Plan for Accelerating Rice Self-Sufficiency in Africa (CIPRiSSA): The CIPRiSSA studies are now being used to target investments in the rice sector. Moreover, a Support System for Accelerating Rice Self-Sufficiency in Africa (SSARSSA) has recently been established within the AfricaRice Strategic Support Unit (under the Director General's Office) to sustain the momentum of CIPRiSSA and its expansion to other countries.
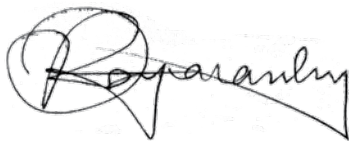
Pan-African breeder and foundation seed capital in M'bé: The establishment of a pan-African breeder and foundation seed capital of the most popular improved rice varieties on the market, was initiated in M'bé by AfricaRice and its partners. It is based on a public–private partnership business model that the Center has developed to enhance the rice-seed value chain.

The model creates synergy between agribusiness and smallholders to meet the seed needs for food security and generate value addition and jobs for youth and women.
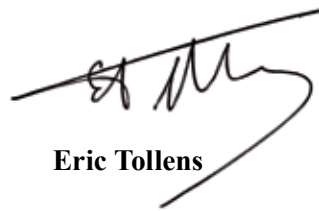
Rice Value Chain Resource Center (RVC-RC): The RVC-RC is a framework integrating research goods and services into rice-producing communities in countries, within the context of an orchestrated rice value chain (linking through contractual arrangements the various actors of the rice value chain, including banks, insurance brokers and viable markets), which will result in the creation of business entities and employment (especially for youth and women). This model will also help every actor of the rice value chain in Africa recognize the importance of research in contributing to the establishment of lucrative businesses. AfricaRice needs to position itself so that it would be recognized as an institution that can do relevant and meaningful development work to boost member countries' rice sectors and economies. This means that the research that has to be done should strictly respond to the demands of Member States, which will motivate their investments in AfricaRice's research in particular and its sustainability in general.

Harold Roy-Macauley

Eric Tollens

Creation of a mini-core collection for African rice *(Oryza glaberrima)*

"Variation present in accessions conserved in genebanks can best be used in plant improvement when it is properly characterized," say head of the AfricaRice Genetic Resources Unit Marie-Noëlle Ndjiondjop and her co-workers.[1]

With about 2700 accessions, AfricaRice holds the largest collection of African rice in the world. An indication of the variety contained in the collection is seen in the diversity of seed types (see photo). Some of the materials were used as donor parents in developing the 'New Rice for Africa' (NERICA) varieties in the 1990s and 2000s, and the Advanced Rice for Africa (ARICA) varieties in the 2010s.

Oryza glaberrima samples have also been sent to researchers (mainly breeders) in the International Center for Tropical Agriculture (CIAT) and the International Rice Research Institute (IRRI), advanced research institutes in six countries (146 samples) and 26 national programs in Africa (607 samples). This is a demonstration of the value of the African rice in the quest for improving rice breeding in general.

The African rice accessions maintained in the AfricaRice genebank represent potential sources of traits for developing improved varieties, which could respond to a wide range of agricultural- and food-systems challenges. Since detailed phenotyping of a large germplasm collection in replicated multi-location multi-year trials is very expensive and time-consuming, AfricaRice used high-density molecular markers to select a 'mini-core collection'. This represents a smaller set of African rice germplasm, which can easily be distributed to rice research and breeding communities around the world to promote the use of the species.

"For the molecular analysis, we used next-generation genotyping by sequencing technology, which is cheaper and high throughput," says Ndjiondjop.

Using the large AfricaRice collection for the first time, the team confirmed previous results of rice research scientists: that African rice has a low level of genetic diversity compared to the Asian rice (*O. sativa*) and even its wild relative *O. barthii*.

The analyses revealed five groups of accessions, which are primarily based on country of origin rather than on growing environment. A mini-core of 350 accessions captured 97% of the molecular diversity observed across the entire collection and represents nearly every country of origin. Seed multiplication of the mini-core has been completed and preparation for detailed phenotypic evaluation is underway. This will include nutritional value and agronomic traits under abiotic and biotic stresses. Once suitable source accessions have been identified for a particular trait, they can be used by breeders in developing improved varieties.

The creation of a mini-core collection is important in various ways and three ways in which it could be put into use are given below.

Searching for appropriate traits/genes—in particular, response to climate change. A recent study led by the Institut de recherche pour le développement (IRD, France),[2] in collaboration with partners including AfricaRice, has shown that the reduction in genetic diversity observed in African rice is related to a bottleneck during domestication caused by a collapse of the wild ancestor population during the drying of the Sahara. One implication of this is that the surviving African rice passed through extreme climate hardship,

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1. Ndjiondjop M-N et al. 2017. Genetic variation and population structure of *Oryza glaberrima* and development of a mini-core collection using DArTseq. *Frontiers in Plant Science.* doi: 10.3389/fpls.2017.01748.

2. Curby P et al. 2018. The rise and fall of African rice cultivation revealed by analysis of 246 new genomes. *Current Biology.* doi: 10.1016/j. cub.2018.05.066.

An example of seed diversity in the mini-core of African rice.

Neighbor-joining phylogenetic tree of African rice collection based on single-nucleotide polymorphism (SNP) markers. The 350 mini-core accessions are shown in blue.

suggesting that *O. glaberrima* is, in today's terminology, 'climate smart' and a potentially useful source of genes for adaptation to the climate changes that parts of Africa can expect to face in the coming years.

Identifying gaps that will inform further consolidation of the AfricaRice *O. glaberrima* collection. For example, the study to establish the mini-core collection revealed that the over 200 accessions from Togo came from just two sites, and that two accessions were sufficient to cover the genetic variation in Togolese accessions in the collection. Similar situations were noted for several other countries, including Côte d'Ivoire and Nigeria. This strongly suggests that *O. glaberrima* has been under-collected in some countries, and that it would be worthwhile to conduct extensive gap analysis on the collection and distribution of this species, and then plan new collection missions to places for which the genebank has little or no representative germplasm.

Correcting errors that have occurred during germplasm acquisition and routine genebank operations. Species misclassification (misidentification) and handling errors are frequent for various plant species conserved in genebanks. The research showed that about 2% of the African rice accessions were likely misclassified at some stage during germplasm acquisition or routine genebank operations. AfricaRice and partners have identified species-specific diagnostic markers that can be used to trace and correct errors in the future.

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Breakthrough in lowland rice breeding targeting submergence tolerance

Flooding in some parts of the African continent is now a recurrent phenomenon that may be attributable to climate change. It is causing rice production losses especially in rainfed lowland areas. In Nigeria, for example, 22% of rice production loss in 2012 was a result of flooding. In simple terms, rice varieties grown in the flooded areas could not tolerate prolonged submergence. With rainfall predicted to increase in frequency and intensity in parts of the continent, submergence tolerance is a key trait for rice breeders to target.

AfricaRice's response to this challenge was the initiation of breeding activities for submergence tolerance in 2010, within the context of Phases 2 and 3 of the 'Stress tolerant rice for poor farmers in Africa and South Asia' (STRASA) project. This was motivated by persistent requests from national partners with major flood-prone rice areas such as Madagascar, Mali, Nigeria and Sierra Leone.

In 2017, the first two submergence-tolerant varieties, bred through marker-assisted selection, were released in Nigeria as FARO 66 and FARO 67. This was a result of the introduction of the *Sub1* gene for submergence tolerance into popular rice varieties in the country. FARO 66 is based on the high-yielding FARO 52 (a.k.a. WITA 4, which is widely grown in Africa), appreciated for its good grain quality. The new variety is submergence tolerant but otherwise almost identical to FARO 52.

FARO 67 (*see* photo) is based on FARO 60 (a.k.a. NERICA-L 19, also widely grown in Africa) which, because it grows tall under very fertile conditions, is prone to lodging. The new variety is not only submergence tolerant, but also shorter and earlier maturing than the older version (making it less susceptible to lodging) and higher-yielding under both flooded and non-flooded conditions.

"These varieties are so popular that demand — both local and international — is exceeding supply from Nigerian seed production," says lowland rice breeder Ramaiah Venuprasad. "Liberia, Sierra Leone and Uganda have all requested seeds."

To help meet this demand, the two submergence-tolerant varieties are also being multiplied at the AfricaRice M'bé station in Côte d'Ivoire.[3] Meanwhile, upgraded varieties carrying the same *Sub1* gene are in advanced field testing in Madagascar.

Further progress made in breeding for irrigated and rainfed lowland agro-ecosystems are highlighted below.

Senegal. Out of a total of 15 new varieties released in Senegal in 2017, six of them were introduced through AfricaRice (Table 1): (i) AfricaRice aromatic hybrid AR051H,[4] (ii) two other AfricaRice-developed varieties (WAS 73-B-B-231-4 and WAB 2098-WAC3-1-TGR2-WAT 85), (iii) IRRI variety IR 72593-B-3-2-3-8-2B promoted through the STRASA project, (iv) variety OH10 from the Chinese Academy of Agricultural Sciences, and (v) FAROX 521-288-H1 from the Nigerian national program.

All of these varieties were advanced through the evaluation network of the Africa-wide Rice Breeding Task Force. Two of them (WAS 73-B-B-231-4 and the IRRI variety) are salinity tolerant and therefore suitable for both saline irrigated lowlands and mangrove-swamp agro-ecosystems, and three (08 FAN 10, WAB 2098-WAC3-1-TGR2-WAT 85 and FAROX 521-288-H1) are adapted to both irrigated and rainfed lowland systems.

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3. *See* 'Pan-African breeder and foundation seed capital in M'bé' in the Foreword to this annual report.
4. *See* 'Senegal set to release hybrid rice cultivars', *AfricaRice Annual Report* 2016, pages 13–14.

Table 1. Lowland varieties released in 2017

Country	Total	Origin
Ethiopia	4	AfricaRice (2); CIRAD Madagascar (2)
Ghana	6	AfricaRice (1); Nigerian NARS (1); Ghanaian NARS (4)
Nigeria	2	AfricaRice (2)
Senegal	6	AfricaRice (3); CAAS (1); IRRI (1); Nigerian NARS (1)

CAAS, Chinese Academy of Agricultural Sciences; CIRAD, Centre de coopération internationale en recherche agronomique pour le développement; IRRI, International Rice Research Institute; NARS, national agricultural research system.

Ethiopia and Ghana. Between these two countries, a total of 10 lowland varieties were released in 2017 (Table 1). Six of them were introduced through AfricaRice and four were developed by the national program of Ghana. The six varieties released in Ghana are tolerant to iron toxicity and four are aromatic (AGRA-CRI-LOL-1-7, AGRA-CRI-LOL-2-27, CRI-1-11-15-5 and CRI-1-11-15-21), while among the four varieties released in Ethiopia, two are cold tolerant and the other two are drought tolerant.

By becoming a member of the CGIAR Excellence in Breeding platform, which was launched in 2017, AfricaRice now has more scope for assessing its breeding program and, by acting on the resulting recommendations, improving the efficiency of its breeding efforts, especially those geared towards the rapid replacement of old mega-varieties. The platform includes Queensland University (Australia) and other members of the CGIAR Research Program on Rice (RICE: CIAT, IRRI and national partners). RICE will undergo assessment in 2018.

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Submergence-tolerant 'NERICA-L 19–sub1–tall', the line destined to become FARO 67, at a field day in Nigeria

The next generation of rice varieties for the lowlands in the making

Between the 1970s and early 1990s, the Republic of Korea developed 'Tongil' rice varieties through successful crossing of (irrigated) *indica* and temperate *japonica* rice types. Tongil varieties are typically very high yielding in Korea, where all rice is irrigated. In 2010, the Korea–Africa Food and Agriculture Cooperation Initiative (KAFACI) was launched in partnership with 16 African nations to start to bring this valuable germplasm to Africa.

In 2016, AfricaRice, Alliance for a Green Revolution in Africa (AGRA), the Center on Conflict and Development at Texas A&M University (ConDev) and the Korean Rural Development Administration (RDA) launched the 'Africa rice development partnership' project and, shortly after that, AfricaRice and RDA signed a 9-year strategic partnership agreement under KAFACI. In September 2017, KAFACI rice breeder Kang Kyoung-Ho arrived at the AfricaRice Senegal regional station to coordinate the project in 20 African countries.

"Our objective is to use Korean Tongil lines and to create new African Tongil-type lines to develop new 'super-yielding' varieties with good grain quality for the irrigated and rainfed lowlands of Africa," says Kang. "In Tongil materials, the Korean *japonica* parent brings traits that confer high yield potential that may be missing in the typical lowland *indica* varieties."

There is a problem, however: *indica* x *japonica* crosses typically show high levels of sterility (as did the *Oryza sativa* x *O. glaberrima* crosses used in the production of NERICA varieties). To overcome this, Korean breeders performed many crosses to identify fertile combinations and then used anther-culture to rapidly fix Tongil lines. This method is now being used in producing the new African Tongil-type materials.

Meanwhile, the Korean Tongils act as bridge parents for crossing with *indica* rice, displaying much less sterility than direct *indica–japonica* crosses.

Inauguration of the Africa–Korea Rice Breeding Lab (AKRiL), AfricaRice Senegal regional station

Donated by the Rural Development Administration of the Republic of Korea under the Korea-Africa Food and Agriculture Cooperation Initiative, AKRiL will be used to develop elite rice varieties for Africa.

In July 2017, the Africa–Korea Rice Breeding Lab (AKRiL) was inaugurated at the AfricaRice Senegal regional station (*see* photos). The lab has 10 trained staff, including Kang.

In December 2017, KAFACI–AfricaRice ran a workshop for about 30 people, including rice breeders from 19 countries across Africa. "The workshop was designed to level the playing field for African rice breeders," says Kang, "as there is huge diversity between the most advanced facilities on the continent and those who conduct almost no breeding of their own." Consequently, the workshop covered the basics of modern rice breeding and introduced the participants to standardized testing, recording and selection methods to improve the quality of rice breeding data. At the end of the workshop, each breeder was given seeds of Tongil materials selected by the participants as a whole from observational yield trials during their visit.

"Each country received seeds of materials to test for adaptability to their home environments," says Kang. "They may decide to promote some of these as varieties in their own right, but more importantly they should be used in national breeding programs."

In 2016 and 2017, the Africa-wide Rice Breeding Task Force sent seven and then five Tongil lines, respectively, for multilocation testing in five countries. Subsequently, Mali and Senegal selected one Tongil line each for advancement in their national breeding programs. These lines were selected for their earliness and high yields relative to local check varieties, and appealing grain quality traits.

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Mapping abiotic stresses of rice

AfricaRice has invested — and continues to make significant investments — in developing rice varieties tolerant to abiotic stresses. But are these varieties getting to the farmers who need them and are we testing them in the right sites?

Answers to these questions could partly be provided through the approach of mapping, which allows the identification of areas where rice is grown under particular stress conditions. AfricaRice crop modeler Pepijn van Oort spent four years preparing such maps for four abiotic stresses.[5]

Drought and cold were simulated for representative sites with the ORYZA2000 crop growth model (AfricaRice version) and then extrapolated using a (Köppen–Geiger) climate zone map. In each country (12 for drought and 19 for cold), a number of sites were selected in major rice-growing areas in different climate zones with the aid of a program developed by the 'Global yield gap atlas' (GYGA) project. For each site, crop growth was modeled with ORYZA2000 (AfricaRice version), AgMERRA weather data and two soil types (typical upland and typical lowland).

"As an off-shoot from this project, we developed the AfricaRice Weather Database," says van Oort, "which is freely available online."[6]

Iron toxicity and salinity risk were mapped with a soil map (Harmonised World Soil Database) and crop maps. All these source data are in the public domain and are open access.

Drought mapping proved problematic as local variation (due to topography) is greater than climate-induced variation. Consequently, mapping on a continental scale is inappropriate and needs to be done at the local level. The work broadly determined, however, that drought is the major abiotic stress likely to affect a third of the rice area in Africa.

Conversely, severe cold was well mapped to specific climate zones but affects only 3–7% of the rice area and these are mainly concentrated in the Sahel and highlands. While iron toxicity is a potential threat in 12% of the cultivated rice area (*see* example map of Côte d'Ivoire), salinity is a problem in just 2% of the cultivated rice area.

Direct and indirect effects of iron toxicity in inland valleys can lead to 40–45% rice yield reductions in lowlands.

Salinity was well mapped for inland sites, but the resolution of the mapping somewhat masked the major impact of salinity in narrow coastal mangrove agro-ecosystems.

With the maps and accompanying tables generated, development agents are better positioned to target stress-tolerant varieties to those countries and areas

5. van Oort PAJ. 2018. Mapping abiotic stresses for rice in Africa: Drought, cold, iron toxicity, salinity and sodicity. *Field Crops Research*, 219: 55–75. doi: 10.1016/j.fcr.2018.01.016.
6. http://eservices.africarice.org/weatherdata/index.php
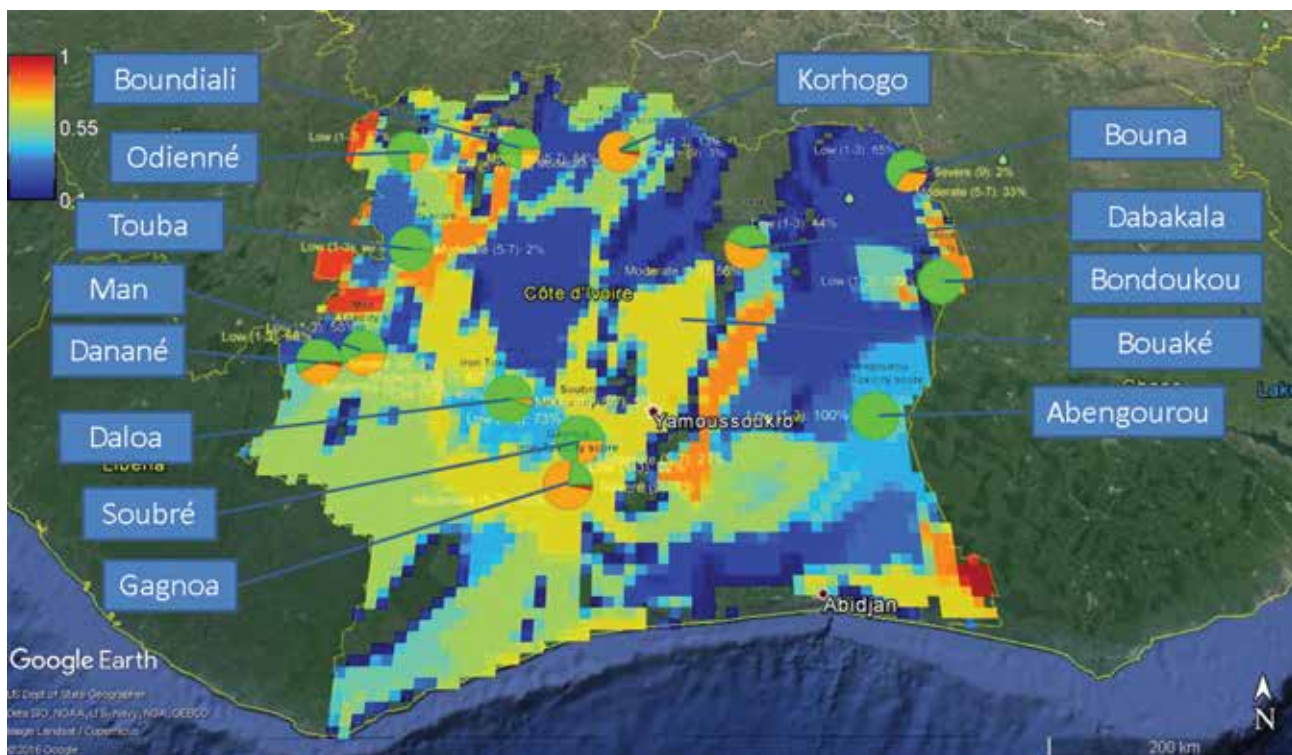
Iron-toxicity risk in Côte d'Ivoire

Probability (0–1, legend top left) of presence of iron-rich soil, on the standard background of Google Earth. Such maps are available for all African countries. The added pie charts show the frequency of observed leaf bronzing — low (green), moderate (orange) and red (severe) — used for validation.9 Note: iron toxicity occurs almost solely in poorly drained rainfed lowlands and very rarely in rainfed uplands or well-drained irrigation schemes; in the calculations of area potentially affected by iron toxicity, this soil map was combined with a rice area map.

that need them. At the same time, the data enable researchers to select stress hot spots in the various climatic zones that are close to non-stress areas for screening their materials.

"AfricaRice has a good track record in variety dissemination, particularly with the NERICA varieties in the early 2000s," says van Oort. "The outputs of this project mean that we now have the means to disseminate the new generation of stress-tolerant varieties to those areas that desperately need them."

All the maps and tables generated by the project are publicly available.[7]

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7. https://dataverse.harvard.edu/dataverse/AfricaRice?q=Abiotic+stress+maps+for+rice+(STRASA)

8. Current affiliation: Wageningen Plant Research.

9. Chérif M, Audebert A, Fofana M and Zouzou M. 2009. Evaluation of iron toxicity on lowland irrigated rice in West Africa. *Tropicultura*, 27: 88–92.

Toward sustainable farming systems

From 2012 to 2017, the Africa-wide Rice Agronomy Task Force developed and tested farm-level technologies to improve rice productivity in Africa.[10] Over five years, the task force sought to quantify yield gaps and their sources, introduce and validate new technologies, and test a 'basket' of good agricultural practices (GAPs) (*see* photo, below). It identified a number of GAPs for increasing rice yield, including fertilizer management (especially via RiceAdvice[11]), weeding frequency and use of mechanical weeders, use of certified seed of improved varieties, bunding and field-levelling.

The AfDB-funded 'Support to agricultural research for development of strategic crops in Africa' (SARD-SC) project (2012-2017), which included the testing and dissemination of GAPs, found that the adoption of GAPs did not significantly improve rice yields in irrigated lowlands but doubled yields under rainfed lowland conditions (1.8−4.8 t/ha compared to

In 2017, the Agronomy Task Force teamed up with private company Intermech in Tanzania to begin production of motorized weeders.

0.8– 2.4 t/ha using farmers' practices) and increased yields under upland rice conditions (1.9–5.1 t/ha compared to 1.5–2.7 t/ha with farmers' practices). More than 50,000 farmers in 21 AfricaRice member countries directly benefitted from these production increases.

In 2017, a motorized weeder (*see* photo, above) for rainfed lowland and irrigated conditions was developed in response to orders from Tanzania and other countries (e.g. Nigeria and Uganda). The motorized weeder was adapted by AfricaRice, working with a private company in Tanzania (Intermech) and national partners, by combining the features of double-row Indian and Japanese-type motorized weeders for effective weed control. Earlier tests of the weeder with 331 farmers were positive, with 85% of them considering it as a cost-effective and time-saving option. It was preferred mostly for its effectiveness for weed control and stability. About 70% of the farmers indicated that they would like to buy and own the weeder individually while 30% preferred to acquire it as a group, because they could not afford to buy it on their own.

On-farm GAP testing experiments in Idete village, Kilombero, Tanzania.

10. For more information on the functioning of the task force, see 'Africa-wide Rice Agronomy Task Force', *AfricaRice annual report* 2012, pages 4–10.
11. www.riceadvice.info/en/

With the research under our belts and the value of the GAP technologies known, the next phase is outscaling of the GAP basket and RiceAdvice at large scale to reach millions of farmers. Much of the outscaling is going to be through the AfDB-funded 'Technologies for African agricultural transformation' (TAAT) Rice Value Chain Compact, which will be implemented in nine countries with spill-over in three countries in the first year.

Meanwhile, the CGIAR Research Program on rice agri-food systems (RICE) was launched in 2017 with five flagship projects. Flagship project 'Sustainable farming systems' aims to develop and deliver sustainable intensification and diversification options for rice-based farming systems. It consists of three clusters of activities: (1) farming systems analysis, (2) intensification and mechanization, and (3) farm diversification. Farming systems analysis provides the entry point for identifying opportunities for intensification and diversification. In collaboration with the Sustainable Rice Platform, the project will contribute to the development, validation and scaling-up of multidimensional sustainability indicators. Innovative technologies are being designed to address issues identified by farming systems analysis, participatory diagnostics and other tools.

Key technologies that are in the scaling phase in Africa include RiceAdvice, direct seeding, alternate wetting and drying (AWD), combinations of stress-tolerant rice varieties and management practices, and conservation agriculture — many of which have been validated by agronomy task force activities. The project considers farm diversification as a major avenue to improving farmers' livelihoods and evaluates other staple crops, pulses, vegetables, fish, livestock and trees as diversification options in rice-based farming systems. Whole-farm productivity, income, gender equity, labor productivity, diet diversity, and environmental sustainability are assessed to make sure that there are no major trade-offs among them.

Map of CGIAR Research Program on Rice Flagship Project 3 (RICE-CRP-FP3),** Support to Agricultural Research for Development on Strategic Crops in Africa (SARD-SC) and Technologies for African Agricultural Transformation (TAAT)* project counties

* Tentative, Africa-wide Rice Agronomy Task Force may not work in all countries; ** in 2017 only, countries may change each year.

With global demand for rice projected to increase by more than 10% by 2030 over 2014 figures, it is essential that rice-based farming systems not only become more productive, but also fully sustainable to avoid the wasteful practice of exhausting the resources in one site and simply moving to another. We must manage farmland worldwide to feed the current population and the generations to come. TAAT, RICE and many other projects in the pipeline will play their roles in this for rice.

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Innovation systems thinking demonstrated in Ankazomiriotra, Madagascar

Among the innovation platforms (IPs) created through the 'Support to agricultural research for development of strategic crops in Africa' (SARD-SC) project, the Ankazomiriotra IP in Madagascar has been growing in number and business relationships.

Initiated in July 2015 in upland rice agro-ecosystems in the central highlands of Madagascar, it covers 404 square kilometers with over 30,000 inhabitants in 16 villages. The objective of creating this platform was to improve business relationships along the rice value chain, with an initial focus on the introduction of the drought-tolerant and locally preferred rice variety consumed by the communities, NERICA 4, and related good agricultural practices (GAPs).

"When we visited the platform in April 2016, there were a little over 100 members," says AfricaRice social scientist, Josey Kamanda. "Now there are over 400, with 45% of them being women. This is remarkable, as our observation for most IPs has been the reluctance of the IP leadership to quickly expand or draw in new members." Members of the Ankazomiriotra IP come from all 16 villages and include farmers representing a total of 23 farmer organizations, input dealers, transporters, traders, processors, artisans, microfinance providers, and agricultural technicians.

The growth of business relationships has been enhanced through the general motivation of platform members to embrace basic IP principles. During 'innovation

Ankazomiriotra innovation platform actors during field training: chairman (left), facilitator (middle) and member (right).

clinics' organized by AfricaRice, farmers themselves selected GAPs for field-testing, which has resulted in them systematically adopting practices such as the use of quality seed, optimum plant spacing, insecticidal seed treatment, optimum seeding rate, timely weeding, and organic and inorganic fertilizers. This has helped increase not only rice productivity, but also rice area by 52%, corresponding to around 73 hectares.

Despite this breakthrough, the good news for producers is that the price of paddy on the local market has been maintained — the leadership of the IP puts this down to the credit-guaranteed sale mechanism adopted, which has enhanced grain quality and market availability. Subsistence farmers have also converted themselves to seed producers. In the 2017/18 season, a total of 13.5 tonnes of quality NERICA 4 seeds as well as 193 tonnes of seed of other varieties were produced by these farmers, with some of them even selling seed to the World Food Programme.

When AfricaRice provided a range of machinery and equipment to the IP through the Japan Emergency Rice Initiative, the members were so motivated that they used their own resources to construct a storage facility to house them. The operators report very high demand for mechanization services, to the point where it is now proving difficult to satisfy all the requests.

Nirina Jean Patrick Rakotoarivelo, facilitator of the Ankazomiriotra IP (*see* photo, facing page), reports ongoing improvement of relations between the various rice value-chain actors: in particular, relationships between farmers and seed producers, and the microfinance provider and other value-chain actors. Moreover, collaboration with a local bean IP provided the critical mass necessary to advocate for support to agriculture, such as aggregation and transport services. The inter-IP collaboration has also enhanced crop rotation.

Rakotoarivelo also reports ongoing need for capacity-development in governance, leadership and the use of new technologies (especially RiceAdvice), and

Rice harvest in the Ankazomiriotra community, Betafo District of Vakinankaratra Region, Madagascar.

training for artisans in the fabrication of the ASI thresher–cleaner and seeders. Sidi Sanyang, leader of the AfricaRice Rice Sector Development Program indicates that some of these issues will be tackled under the new 'Technologies for African agricultural transformation' (TAAT) project.

While the IP has established and maintains a working relationship with a local microfinance provider, it is also seeking a capital loan from the Bank of Africa to build an 'aggregation center' comprising storage warehouse, and processing and marketing facilities.

"The outstanding feature of the Ankazomiriotra IP is its desire to grow," says AfricaRice rice value chain technology transfer officer Abiba Omar Moussa. "According to the latest report from Rakotoarivelo, there is an ongoing objective to increase the membership of the IP and to extend its area of influence to neighboring communities." This is because the people of the Ankazomiriotra IP seemingly think they are into a profitable business and are happy and keen to share this with their neighbors far and wide. Long may this innovation systems thinking continue!

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Valuation of rice postharvest losses in sub-Saharan Africa

Estimated figures for postharvest losses in rice in Africa have been around for many years. Some authors have even claimed up to a 50% loss during postharvest processes. In an attempt to render these figures scientifically viable, AfricaRice carried out a study on postharvest losses from the field to the market in seven countries with the aim of determining, in physical and monetary terms, postharvest losses; the segment of the value chain where these losses occurred as well as the magnitude of the losses; and establishing a protocol to measure changes in postharvest losses in the future. This study was conducted within the context of the 'Rice post-harvest project' funded by Global Affairs Canada and the 'Support to agricultural research for development of strategic crops in Africa' (SARD-SC) project funded by the African Development Bank (AfDB).

The methodology consisted of the establishment of an experimental protocol including the measurement of both quantitative (harvesting, threshing, drying, parboiling, milling and storage) and qualitative (impurities/cleanliness, head-rice/broken-rice ratio, grain dimensions, swelling capacity, and chalkiness) parameters. The protocol was validated by the national

agricultural research institutes through the Africa-wide Postharvest and Value Addition Task Force.

It should be noted that not all countries were able to look at every segment of their rice value chain, in part because some countries do not have every segment (e.g. there is no parboiling in Uganda) and in part because some national partners did not have enough resources to cover all segments in the time available.

As such, detailed results were best considered on a 'losses per value-chain segment' basis. Two scenarios were considered for the measurements: farmers' 'traditional' conditions and practices (scenario 1), and 'ideal' conditions in the form of the best currently available postharvest practices and technologies (scenario 2) (*see* photos for example of 'traditional' and 'ideal' drying floors).

The study revealed that average postharvest loss in study sites for scenarios 1 and 2 were estimated at 14% and 2.5%, respectively, while qualitative losses accounted for 20% of total postharvest losses. Harvest timing was revealed as a major contributor to postharvest losses. "Local practice is to harvest rice with low moisture content to aid threshing," says

Traditional rice drying (left: Goronyo, Nigeria) and improved rice drying surface (right: Glazoué innovation platform, Benin). The clean concrete surface and surrounding walls of the improved infrastructure protect the drying rice from a high proportion of the impurities that laying the tarpaulin on the ground exposes rice to in traditional drying.

AfricaRice grain quality and postharvest specialist Sali Ndindeng, "but this leads to massive losses due to grain-shattering in the field. This is because the grains are, very often, left to dry for a long time.

Analysis of a combination of plant morphological characteristics and grain moisture content reveals that the best time to harvest rice in order to minimize shattering, in-field stacking, and threshing losses, is when the grains have 20–22% grain moisture. Timely harvest of grain with this grain moisture content can save up to 23% of rice yields." This new research estimates overall postharvest losses for sub-Saharan Africa as a whole in the range of 9% to 17%. This was estimated to be worth a staggering US$ 14–600 million a year. Yes! Over half a billion dollars! What, is most surprising is that those countries that produce the most rice have the highest losses — in particular Nigeria, Mali and Sierra Leone.

The good news, however, is that the adoption of current best practices can reduce postharvest losses to 2.5%, salvaging 10–15% of the continent's rice yield. Furthermore, this study has formed the basis for targeting critical areas of intervention by AfricaRice, in the struggle to reduce postharvest losses. For example, farmers who are members of innovation platforms established in the rice sector development hubs, have been trained to identify the best time to harvest rice (i.e., when the grains have 20–22% grain moisture).

Experience has shown that while training significantly enhances the value-chain actors' ability to make best use of equipment that is provided and thus their profits, training alone is insufficient — those trained in a piece of equipment who do not have the resources to acquire that equipment tend to revert to traditional practices after the training.

"When you compare the increased yield provided by new varieties with the grain that can be saved by improving postharvest handling and processing, investment in postharvest practices and equipment should be at least at par with that for variety development," says Ndindeng. This study also forms a scientific basis for policy- and decision-making by governments with terms of investments to reduce postharvest losses.

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The use of improved, modern practices in processing rice could result in significant gain in milled rice.

The rise of locally produced aromatic rice in Senegal

Before the rice-price crisis of 2008, the approach to developing the rice sector in Senegal focused on the *supply* chain. After the crisis, the focus shifted to the *value* chain — what do consumers value and what do they want when they go to the market to buy rice?

The veracity of such a statement could be demonstrated by the current phenomenon observed in the Senegal rice market. Demand for aromatic (fragrant) rice is increasing rapidly in urban parts of Senegal such that it can now be estimated to make up about 25% of Senegalese rice imports. To boost local production of aromatic rice, in 2009, Senegal released three AfricaRice aromatic varieties — Sahel 177, Sahel 328 and Sahel 329. These varieties have now become part of the farm-level seed mix in production areas. The question is, however, are they valued by consumers?

In an attempt to answer this question, AfricaRice carried out experimental auctions with women shoppers at a major market in Dakar, the capital city, which is home to 75% of Senegal's urban population.

The experimental auction was to determine the willingness of the urban population of Senegal to pay for imported and local aromatic rice varieties in comparison with 'standard' imported non-aromatic rice (*see* photo below).

"Women shoppers were chosen because they are the major decision-makers in rice purchases," says AfricaRice value-chain economist Mandiaye Diagne, "and, predictably, 89% of our sample said they were involved in rice purchase decisions for their households."

Three quarters of consumers were willing to pay an average of 20% price premium for aromatic rice over 'standard' non-aromatic rice, corresponding to about US$ 0.12 more per kg. While local rice typically attracts a significantly discounted price compared to

Experimental auctions were carried out by AfricaRice to determine the willingness of the urban population of Senegal to pay for imported and local aromatic rice varieties in comparison with 'standard' imported non-aromatic rice.

imported brands, the three locally produced aromatic rice varieties attracted premiums of only 4–8% less than those for imported aromatic brands. Moreover, those who had already made up their minds to buy *domestic* aromatic rice, were willing to pay a premium of up to 35%, corresponding to $0.20 more per kg.

Major factors influencing this willingness to pay were ethnicity, household size and awareness of the existence of (imported and local) aromatic rice. Four ethnic groups that make up 87% of the Senegalese population (Wolof, Sereer, Pulaar and Diola) were willing to pay a premium for aromatic rice. While the historical relationships between ethnic groups and rice were not part of this study, it is well known (in Senegal) that the Diola have a stronger cultural and social relationship with rice than any other groups. This was also true for populations buying for larger households, though only marginally so, and those who know about and prefer aromatic rice (for its aroma and taste) and were aware of its availability on the local market.

One disadvantage of aromatic rice vis-à-vis local rice producers, however, is the typically low yields of aromatic varieties compared with non-aromatic ones.

This is compounded by the low availability of certified seed in Senegal. These issues point to the need for upgrading the aromatic-rice value chain, especially in terms of seed production, harvesting and postharvest handling. What is lost in terms of productivity is, however, seemingly gained with the price premiums these varieties attract.

Given consumers' keenness to purchase aromatic rice, there is also a need to raise awareness about its existence on the market through advertising. The packaging and branding segment of the value chain also needs to make a strong distinction for locally produced aromatic rice, so that it could be easily identified in the market by customers.

"In 2013, the total production of fragrant rice in Senegal was estimated at 40,000 tonnes, representing around 15% of the total fragrant rice imports of the country," says Diagne. "By upgrading the fragrant-rice value chain, Senegal will move ever closer to its goal of rice self-sufficiency, not just in terms of total quantity, but also in terms of delivering the kinds of rice that consumers want to buy and eat."

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In addition to aromatic Sahel varieties (Sahel 177, Sahel 328 and Sahel 329) that are making rapid headway in Senegal, AfricaRice has also developed the aromatic hybrid variety, AR051H, which was released in Senegal in 2017.

Positive impact of improved rice varieties for millions in sub-Saharan Africa

Since the creation of AfricaRice in 1971, the development and dissemination of improved rice varieties for local rice agro-ecosystems, such as the WABs, the WAS, the WITAs, the Sahels, the NERICAs and the ARICAs have been a major component of the Center's work. The mid-1990s saw the development of the first NERICAs.

An analysis of the impact of improved rice varieties on poverty reduction and food security in Africa,[12] based on a metadata analysis of published impact assessments for the period 2000–2014 and data from farm household surveys (*see* photo) undertaken in 2014 in 16 countries, was published in 2017. "The objectives were to determine where impact was effectively occurring along the 'impact pathway', how many people were no longer poor or food insecure because of the adoption of improved varieties, and the 15-year trends," explains AfricaRice impact assessment economist Aminou Arouna.

The study revealed that the adoption of NERICA varieties by farmers had increased from about 10% in 2000 to about 53% in 2014, with a huge leap observed after the 2008 rice crisis. A combination of increasing number of adopters and increasing area planted with improved varieties by adopters, rice area under NERICA varieties grew from about 200,000 hectares in 2006 to 650,000 ha in 2008 and then to 1.4 million ha in 2014.

Farmers and AfricaRice partners from Ilonga Agricultural Research Institute (ARI-Ilonga) during a survey on the impact of improved rice varieties at Morogoro (Tanzania).

12. Arouna A, Lokossou JC, Wopereis MCS, Bruce-Oliver S and Roy-Macauley H. 2017. Contribution of improved rice varieties to poverty reduction and food security in sub-Saharan Africa. Global Food Security, 14: 54–60.

For yield, however, a decreasing trend was observed over time. This could be attributed to the fact that rice farmers still practise the habit of saving grain as seed for the next season. Because rice is a self-pollinating crop it 'breeds true'; however, the viability of saved grain used as seed decreases over time.

Income generated from the sale of rice has increased over time, and this could be attributed to increasing grain price on the market and farmers increasing the areas cultivated with improved varieties. In the case of farmers who have adopted NERICA, their income increased from an average of US$ 25 per capita in 2004 to $58 per capita in 2014. The adoption of improved rice varieties has resulted in about 1 million households (corresponding to 8 million people), in 16 countries in Africa, having been lifted out of poverty and 0.9 million households (corresponding to 7.2 million people) are no longer food insecure (*see* Figure).

The study characterized non-adopters as those who have never heard about the new varieties plus those who, while knowing they exist, have no access to them.

To enhance the adoption of improved varieties, focus should be on increasing awareness of the existence of improved varieties, increasing awareness of farmers on the importance of replenishing their seed regularly by the use of certified seeds of improved varieties to maintain their yield advantages, and facilitating the access of farmers to these seeds.

With increasing effects of climate change, the current crop of high-yielding varieties is not going to be enough. For the future, varieties with high yield and adapted to climate change (drought, flood, salinity, etc.) — such as the ARICAs — will be required. About 18 ARICAs are already available and focus of diffusion should be on ARICA and other new varieties such as the Tongil-types.

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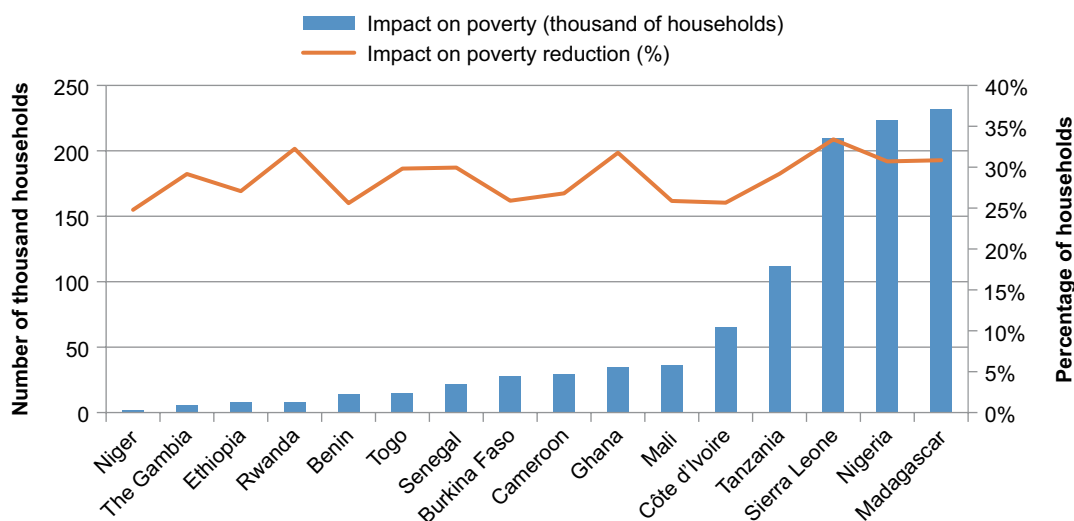
Percentage and number of households saved from poverty due to adoption of improved rice varieties in SSA countries in 2014.

Rice data as public goods to enhance agricultural development

Public goods generated through research should not be limited only to technologies, tools, models, practices and methods, and policy options. These goods, which are to be freely available to the public, are 'built' on data, which also should be freely available to the public.

The CGIAR Platform for Big Data in Agriculture was established in 2017, "to increase the impact of agricultural development by embracing big data approaches to solve development problems faster, better and at greater scale than before".[13] In effect, it is all about making agricultural data available to the public for achieving greater development impact. The platform is led by CIAT and the International Food Policy Research Institute (IFPRI) and includes all 15 CGIAR Centers.

The willingness of AfricaRice to make rice data available to the public is confirmed by the Center's publishing policy that demands "open access, open data". The Center adopted an Open Access and Data Management Policy in 2014 that includes implementing CGIAR recommendations on making information products such as data and publications open access.

The CGIAR Data Management Task Force, with representatives from each of the Centers (including the AfricaRice biometrician), defined a core set of 15 metadata elements.[14]

Its willingness to take this further by ensuring that rice data generated contributes effectively to agricultural development is illustrated by the words of the AfricaRice biometrician Ibnou Dieng: "Everything we

do in the AfricaRice Data Integration and Biometrics Unit now comes under the umbrella of the CGIAR platform for big data in agriculture". The platform facilitates access to data, networking and partnership-building among scientists, academia and the private sector, and demonstrates the power of CGIAR big data analytics and use of data in pilot-testing technologies to be scaled up. The platform also supports projects that convert data into decision-making tools.

AfricaRice has since developed a standard template and workflow for the collection and collation of raw data and associated metadata. Activities of the task force are now carried out under Pillar 1 of the big data platform, which addresses access to data.

Since most CGIAR Centers were using Harvard University's Dataverse as primary repository for open data, AfricaRice relocated its existing open data from CKAN (Comprehensive Knowledge Archive Network) to Dataverse (*see* illustration of the AfricaRice Dataverse home screen),[15] which has the advantage of generating a DOI (digital object identifier) for each dataset, so that it can be referenced just like any other publication.

In addition, the big data platform is taking steps toward data discoverability across CGIAR with the open Dataverse CGIAR repositories visible through GARDIAN (Global Agricultural Research Data Innovation & Acceleration Network), a data harvester.[16]

By the end of 2017, AfricaRice had made the following datasets openly available online: abiotic-stress maps

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13. https://bigdata.cgiar.org/about/

14. 'Metadata' describe datasets in terms of such attributes as objective, location and year of study, variable/trait descriptions, units of measurement or category descriptions, and reference to documented methods used to generate the data, as well as the researchers who gathered and processed the data.

15. https://dataverse.harvard.edu/dataverse/AfricaRice

16. http://gardian.bigdata.cgiar.org/index.php#!/

Everything that AfricaRice does revolves around data. The WeedManager app, for example, is based on datasets from extensive research.

for rice;[17] long-term trials on rice double-cropping in Senegal; AfricaRice Weather Database; weed inventory and characteristics; Africa-wide Rice Breeding Task Force trials in 13 countries from 2015–2016; diagnostic survey of local rice-based production systems in Africa in 14 countries from 2012; and yield-gap surveys in 19 countries from 2012–2014.

"We have made great strides in making our data freely and publicly available," says Dieng, "and we now have mechanisms in place to ensure open access to all future data for the benefit of researchers and development practitioners worldwide and, ultimately, farmers and other rice value-chain stakeholders."

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17. https://dataverse.harvard.edu/dataverse/AfricaRice?q=Abiotic+stress+maps+for+rice+(STRASA).

GREAT step in approach to building gender capacity at AfricaRice

"When I took on the mantle of AfricaRice gender focal person, I felt that I needed some deeper understanding of how to integrate gender not only in my own research, but also in the Center's strategies," says value-chain economist Gaudiose Mujawamariya. AfricaRice's understanding of gender issues was deepened in 2017 through involvement in the 'Gender-responsive researchers equipped for agricultural transformation' (GREAT) project.

The GREAT project, which is a collaboration between Cornell University (USA) and Makerere University (Uganda), runs courses to "equip researchers to create more inclusive and effective agricultural systems by addressing the priorities of both women and men in sub-Saharan Africa".[18] AfricaRice's proposal to apply gender principles in the 'Stress tolerant rice for Africa and South Asia' (STRASA) project won a place on the 2017–2018 course, 'Gender-responsive cereal grains breeding' (*see* photos).

A major outcome of the training was the realization that gender issues needed a shift of emphasis in AfricaRice. While the STRASA protocol requires that at least 30% of participating farmers are women, STRASA and the majority of other AfricaRice projects have typically included farmers — women farmers in particular — in technology testing and transfer rather than technology development.

"Despite more women farmers participation in STRASA participatory varietal selection activities," says high-altitude rice breeder Negussie Zenna, "the participation alone did not seem to contribute to higher adoption rate of new varieties unless women were empowered to make decisions on which variety to adopt at a household level and have access to and control over the resources necessary to cultivate the variety of their choice." For researchers to develop technologies that respond to the needs of both men and women, both men and women farmers need to be involved from the start, in order to identify their own specific needs.

"It was the right time for this course," says Mujawamariya, who wants to use the work as a launchpad for increasing institutional awareness of gender work. While it would be impractical for all AfricaRice researchers to attend a GREAT course, "it would be good for project coordinators to do so," says Mujawamariya. But GREAT runs one course a year, and entry to that course is competitive.

Mujawamariya and Zenna thus have the important task of sensitizing Center management, colleagues and partners. One proposal advanced by management is to carry out in-house training, sharing practical tools for integrating gender research and building on a gender-dissemination guide developed by a former gender focal person. "We will also encourage our Capacity Development Unit to include gender as part of its core course for all trainees, including our national partners," says Zenna.

"Gender is more than a box-ticking exercise for a donor," says Mujawamariya, "it requires funding to have a positive impact in every research-for-development project we do. It is good to have a male researcher, a breeder, already on board with gender-sensitivity, as he is well placed to advocate to our male colleagues and fellow researchers."

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18. www.greatagriculture.org/

Negussie Zenna (right) following up interviews being administered to farmers on their households varietal preferences and choices as part of the AfricaRice project for GREAT

Gaudiose Mujawamariya (right) and Negussie Zenna in discussion with Hale Ann Tufan, one of the GREAT principal investigators

Excellence in capacity development: Awards for AfricaRice PhD students

AfricaRice has a long track record of hosting, supervising and supporting postgraduate students pursuing research on rice in Africa. In 2017, ten PhD students successfully defended their theses and were accorded doctoral degrees. Of these 10, four have also won awards for various aspects of their work.

Shadrack Kwadwo Amponsah

Shadrack Amponsah is a research scientist in agricultural mechanization at the Council for Scientific and Industrial Research Crops Research Institute, Kumasi, Ghana. He received the award of the 'Most Published Author (Engineering publications)' in the category Practitioners/Projects from the Ghana Institution of Engineering during the fourth Engineering Excellence Awards, 2017. Amponsah's research, co-supervised by AfricaRice scientists, Sali Ndindeng and Jean Moreira, evaluated field performance and economic feasibility of various rice harvesting systems. The research confirmed that total paddy yield and grain quality are influenced by factors such as rice variety, good crop management practices, timely harvesting of paddy, and good processing and handling methods. Amponsah also showed that the mechanized harvester tested offered profit margins of about 200%, with break-even (paying off the capital purchase) occurring in just two seasons. Such information is of great value to policy-makers looking into agricultural mechanization, while it also guides breeders toward varieties with low shattering rate and good threshability.

Preliminary on-station testing and evaluation of the Sifang mini rice combine at AfricaRice Cotonou station: Shadrack Amponsah with colleagues Ella Djidohokpin (center) and Fatima Asana (left).

Stella Kabiri-Marial

Stella Kabiri-Marial currently works as a senior research officer and is program leader for Technology Promotion and Outreach at the National Agricultural Research Organisation in her home country of Uganda. Kabiri-Marial was awarded the prestigious Best Poster Award at the 2015 biennial meeting of the European Weed Research Society for her PhD research on the parasitic weed *Rhamphicarpa fistulosa*, which was conducted at AfricaRice and Wageningen University. *Rhamphicarpa* has become a problem for rice cultivation as farmers have increasingly expanded production into the African lowlands. Co-supervised by former AfricaRice agronomist Jonne Rodenburg, Kabiri-Marial found that *Rhamphicarpa* requires daylight and water-saturated soil. While the parasitic weed can grow without a rice host, such plants are shorter than those on rice and produce a fraction of the seed. *Rhamphicarpa* manipulates rice to produce carbohydrates, which it then siphons off via the root. The research showed that management of *Rhamphicarpa* is necessarily going to have to be very different from that of the other rice-parasitic weed, *Striga*, which infests upland rice. She has, however, laid some of the groundwork for the future *Rhamphicarpa* management as more rice is affected due to increasing rice area and climate change.

Stella Kabiri-Marial's PhD graduation at Wageningen University & Research: handing her the degree is her promoter, Prof. Niels Anten; they are watched by (from left to right) Onzima Robert, her paranymph during the defense of her thesis, Jonne Rodenburg, and Lammert Bastiaans, her day-to-day supervisor.

19. See also 'Profiles of selected PhD candidates — Stella Kabiri', *AfricaRice annual report 2012*, pages 52–53.

Delphine-Lamare Mapiemfu

Delphine Mapiemfu won the Best Junior Researcher Award from the Ministry of Scientific Research and Innovations of her home country of Cameroon. Her research was on the impact of farming and postharvest practices on harvest and postharvest losses. The research made significant and new contributions toward identifying reliable factors for modelling postharvest losses in Cameroon and the development of site-specific recommendations to reduce such losses. In particular, Mapiemfu identified where exactly in the value chain losses were occurring, the influence of biophysical factors on grain quality, the importance of preharvest practices for grain quality, and the value of the GEM parboiling technology for reducing both qualitative and quantitative losses. Reducing rice losses is a key component in increasing the quantity and quality of rice produced on the continent. Sali Ndindeng supervised her work at AfricaRice.

Cynthia Nwobodo

Cynthia Nwobodo, co-supervised by head of AfricaRice Knowledge Management Unit Marc Bernard, won the Vice Chancellor's Postgraduate Award of the University of Nigeria for her studies on 'Communication linkages among actors in the rice value chain in Nasarawa and Benue States, Nigeria'. Communication among the various actors in a value

Postharvest loss assessment survey in Ndop rice sector development hub, Cameroon: Delphine Mapiemfu (center) and colleague interview a local farmer

chain is of immense value if the value chain is to be efficient. Nwobodo found that while formal horizontal linkages (between actors of the same type) were embraced by input dealers, processors and traders, few farmers belonged to associations, and formal links between consumers were entirely lacking. Vertical linkages between different levels of the value chain and with support actors were also very few. The most disadvantaged were women, illiterate and poor value-chain actors, who all had very little communication with peers and other actors. Moreover, value-chain actors were not seeking information which would facilitate them linking with others or for financial advice. This scenario is about as far from a good business model as it is possible to get and helps explain the lack of competitiveness in the Nigerian rice value

chain, which has been attributed to information asymmetry. It also indicates the amount of work that may be required to upgrade the value chain to increase efficiency from farmers to consumers.

"AfricaRice is proud of its award-winning students and hopes that they will continue to thrive in agricultural research and development, and successfully transfer their passion and knowledge to their youngsters," says head of AfricaRice Capacity Development Unit Khady Nani Dramé. *"Seeing a student complete his/ her degree training with such a great achievement is so fulfilling."*

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Training of Agricultural advisory service providers from the National Agricultural and Rural Advisory Agency of Senegal (ANCAR) in rice production techniques at the AfricaRice Regional Training Center in Senegal, October 2017.

Finance

Statements of activity (expressed in thousands of US$)

	Total 2017	Total 2016
Revenue and gains		
Grant revenue		
Windows 1 and 2	3,807	4,249
Window 3	4,323	6,304
Bilateral	10,475	13,275
Total grant revenue	**18,604**	**23,828**
Other revenue and gains	388	456
Total revenue and gains	**18,992**	**24,284**
Expenses and losses		
Research expenses	17,153	19,811
CGIAR collaboration expenses	188	581
Non-CGIAR collaboration expenses	1,807	2,893
General and administration expenses	1,786	2,665
Other expenses and losses	–	–
Total expenses and losses	**20,934**	**25,950**
Operating surplus/deficit	(1,941)	(1,666)
Gain/loss on sale of assets	35	0
Restructuring cost/others	(1,260)	(211)
Financial income	6	14
Financial expenses	(190)	(379)
Surplus (Deficit) for the year	**(3,351)**	**(2,242)**

List of donors

AfricaRice sincerely thanks all the donors who have generously contributed to its success:

- AfricaRice Member States
- African Development Bank (AfDB)
- Alliance for a Green Revolution in Africa (AGRA)
- Arab Bank for Economic Development in Africa (BADEA)
- Belgium
- Bill & Melinda Gates Foundation
- Canada
- Chinese Academy of Agricultural Sciences (CAAS)
- CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)
- CGIAR Platform for Big Data in Agriculture
- CGIAR Research Program on Policies, Institutions, and Markets (PIM)
- CGIAR Research Program on Rice Agri-food Systems (RICE)
- Côte d'Ivoire
- Crop Trust
- Department for International Development (DFID)
- European Union (EU)
- Food and Agriculture Organization of the United Nations (FAO)
- German Federal Ministry of Economic Cooperation and Development (BMZ)
- German Society for International Cooperation (GIZ) GmbH
- International Fund for Agricultural Development (IFAD)
- Japan (MAFF, MOF, MOFA)
- Japan International Cooperation Agency (JICA)
- Japan International Research Center for Agricultural Sciences (JIRCAS)
- Liberia
- Nigeria
- Netherlands Organisation for Scientific Research (NWO)
- Rural Development Administration (RDA), South Korea
- Syngenta Foundation for Sustainable Agriculture (SFSA)
- Technical Centre for Agricultural and Rural Cooperation ACP-EU (CTA)
- United States Agency for International Development (USAID)
- West African Economic and Monetary Union (UEMOA)
- West and Central African Council for Agricultural Research and Development (WECARD/CORAF)
- World Bank

Training 2017

AfricaRice training program (courses)

84 Training courses run in 2017

34 Locations   in **15** countries

12,653 Total trainees

Postgraduate trainees

28 Total female postgrads

47 Total male postgrads

From **22** countries

56 PhD students
… of whom
21 Female
35 Male

19 MSc students
… of whom
7 Female
12 Male

With **34** universities

In **17** countries

19 Funding sources

AfricaRice publications 2017

43 Articles in Thomson Reuters–list journals

33 Articles in other peer-reviewed journals

11 Book chapters

11 Conference papers

7 Articles in *Rice Today*

3 Others / reports

7 Videos

... in **2** languages

Selected titles in Science Citation Index (SCI) and Science Citation Index Expanded (SCIE) journals

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Abbreviations

AfDB	African Development Bank
AfricaRice	Africa Rice Center
AGRA	Alliance for a Green Revolution in Africa
a.k.a.	also known as
AKRiL	Africa–Korea Rice Breeding Lab
ARICA	Advanced Rice for Africa (varieties)
AWD	alternate wetting and drying
CAADP	Comprehensive Africa Agriculture Development Programme
CAAS	Chinese Academy of Agricultural Sciences
CIAT	International Center for Tropical Agriculture
CIPRiSSA	Continental Investment Plan for Accelerating Rice Self-Sufficiency in Africa
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement (France)
CoM	Council of Ministers (AfricaRice)
DonDev	Center on Conflict and Development at Texas A&M University
doi / DOI	Digital Object Identifier
GAP	good agricultural practice
GARDIAN	Global Agricultural Research Data Innovation & Acceleration Network
CKAN	Comprehensive Knowledge Archive Network
GREAT	Gender-Responsive Researchers Equipped for Agricultural Transformation
GYGA	Global Yield Gap Atlas (project)
ha	hectare
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IRD	Institut de recherche pour le développement (France)
IRRI	International Rice Research Institute
KAFACI	Korea–Africa Food and Agriculture Cooperation Initiative
kg	kilogram
Mt	million tonnes
NARS	national agricultural research system(s)
NERICA	New Rice for Africa (family of interspecific rice varieties for uplands)
NERICA-L	New Rice for Africa (family of interspecific rice varieties for lowlands)
PhD	Doctor of Philosophy (doctoral degree)
RDA	Rural Development Administration (Republic of Korea)
RICE	CGIAR Research Program on Rice

SARD-SC	Support to Agricultural Research for Development of Strategic Crops in Africa (project)
SNP	single-nucleotide polymorphism
SSARSSA	Support System for Accelerating Rice Self-Sufficiency in Africa
STRASA	Stress Tolerant Rice for Poor Farmers in Africa and South Asia (project)
TAAT	Technologies for African Agricultural Transformation (project)
US	United States
USA	United States of America
WAAPP	West Africa Agricultural Productivity Program
WECARD/CORAF	West and Central African Council for Research and Development

About CGIAR

CGIAR is a global research partnership for a food-secure future. CGIAR science is dedicated to reducing poverty, enhancing food and nutrition security, and improving natural resources and ecosystem services. Its research is carried out by 15 CGIAR Centers in close collaboration with hundreds of partners, including national and regional research institutes, civil society organizations, academia, development organizations and the private sector.

For more information, visit www.cgiar.org

The Centers

AfricaRice	Africa Rice Center (Abidjan, Côte d'Ivoire)
Bioversity	Bioversity International (Rome, Italy)
CIAT	International Center for Tropical Agriculture (Cali, Colombia)
CIFOR	Center for International Forestry Research (Bogor, Indonesia)
CIMMYT	International Maize and Wheat Improvement Center (Mexico, DF, Mexico)
CIP	International Potato Center (Lima, Peru)
ICARDA	International Center for Agricultural Research in the Dry Areas (Beirut, Lebanon)
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics (Patancheru, India)
IFPRI	International Food Policy Research Institute (Washington, DC, USA)
IITA	International Institute of Tropical Agriculture (Ibadan, Nigeria)
ILRI	International Livestock Research Institute (Nairobi, Kenya)
IRRI	International Rice Research Institute (Los Baños, Philippines)
IWMI	International Water Management Institute (Colombo, Sri Lanka)
World Agroforestry	World Agroforestry Centre (Nairobi, Kenya)
WorldFish	WorldFish Center (Penang, Malaysia)

AfricaRice