PART IV
Boosting Agricultural Efficiency and Output through Targeted Interventions
Chapter 15
Increasing Rice Productivity and Strengthening Food Security through New Rice for Africa (NERICA)

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Despite Africa's potentially rich land and water resources, its farmers are among the poorest in the world. Because the vast majority of people in Africa derive their livelihoods from agriculture, the weak state of the sector has profound implications for poverty. Agriculture in Africa needs to internalize the region's biophysical, institutional, and socioeconomic constraints and establish efficient value chains to support sustainable growth and reduce poverty.

Agricultural research can catalyze agricultural innovation and the development of the value chain. A prime example is the New Rice for Africa (NERICA) varieties developed by the Africa Rice Center (AfricaRice) and partners, which gained popularity among Africa's rice farmers in a relatively short period of time. NERICA varieties were developed from crosses between the African species *Oryza glaberrima* Steud. and the Asian species *O. sativa* L., using conventional biotechnology to overcome the sterility barrier between the two species. This chapter describes the history, development, and impact of NERICA and makes recommendations about its expansion.

The Importance of Rice and the Development of NERICA Varieties

Rice has long been the food staple in many traditional rice-growing communities and in major cities in West Africa. It is now the fastest-growing food staple in Africa. Annual per capita rice consumption in West Africa increased from 14 kilograms in the 1970s to 22 kilograms in the 1980s and more than 39 kilograms in 2009. For Africa as whole, annual per capita rice consumption increased from 11 kilograms in the 1970s to 21 kilograms in 2009 (figure 15.1). Since the early 1970s rice has been the number one source of caloric intake in West Africa and the third most important source of calories (after maize and cassava) for the continent as a whole (figure 15.2).

Domestic rice production grew at the rate of 6 percent a year between 2001 and 2005. But production still falls far short of demand. As a result, Africa imports up to 40 percent of its rice consumption. The continent as a whole imports 30 percent of world rice imports, a potentially very risky and unsustainable situation, as shown during the food crisis in 2008. Rice imports cost Africa almost $4 billion in 2009 (Seck et al. 2010)—money that could have been invested in developing the domestic rice sector.

Until the early 1990s, rice breeding programs in Africa worked almost exclusively on improving *O. sativa* lines for Africa's diverse rice growth environments. Some breeders even voted to accelerate the disappearance of *glaberrima* (IRAT 1967), even though *sativa* varieties are generally much more vulnerable than *glaberrima* to the numerous biotic stresses (rice diseases, insect attacks, weeds, and so forth) and abiotic stresses (soil acidity, drought, salinity, iron toxicity, and so forth) of the African environment.
Some visionary breeders thought about combining the favorable characteristics of *O. sativa* with those of *O. glaberrima*. Crossing was difficult, however, because of the sterility barrier between the two species. A few breeders, including breeders from the Institut de Recherche Agronomique Tropicale (IRAT) and the Institute of Savannah (IDESSA) Bouaké, in Côte d’Ivoire, worked on the problem during the 1970s and 1980s (Diagne 2006). Their work did not produce
good results, with the crosses resulting in either sterile offspring or offspring that had some of the undesirable characteristics of the *glaberrima* parent (lodging, shattering, low yield).⁶

Development of the NERICA varieties began in 1991, when AfricaRice initiated an interspecific breeding program for the upland ecosystem. This long-term investment paid off, when breeders eventually overcame the obstacles encountered earlier, through perseverance and the use of biotechnology tools such as anther culture and embryo rescue techniques. In 1994 the first interspecific line with promising agronomic performance was obtained (Wopereis et al. 2008; Jones et al. 1997a, b).⁷ Several hundred interspecific progenies were generated, opening new gene pools and increasing the biodiversity of rice.

The main objective of the breeding work that led to the NERICAs was to combine the high-yielding attribute of *O. sativa* with the resistance of the indigenous *O. glaberrima* to the African environment. Another long-sought attribute for a good upland variety is the ability to provide acceptable yields under the low-input use conditions typical of upland rice farming in Africa. Both objectives have been largely met, as evidenced by the experimental trials data summarized in table 15.A1 and figure 15.A1 in annex 15.A1, which compare the performance of NERICA progenies with that of their *sativa* and *glaberrima* parents and other *sativa* checks under high and low input conditions and under major stresses in upland rice ecologies in AfricaRice's key research sites in Côte d'Ivoire.⁸

Indeed, the agronomic trials data show that the NERICA varieties bring to upland farmers the high yield potential of the *sativa* varieties under both low and high input conditions (see figure 15.A1), with what is in essence insurance against the risk of significant yield losses in the face of major upland biotic and abiotic stresses. Given that the *sativa* and *glaberrima* parents of these first-generation NERICAs are not the best-performing varieties within the two species, there is reason to expect that the performance of the next generations of NERICAs will be much higher.⁹

Through participatory varietal selection (box 15.1), farmers all over Africa have evaluated interspecific lines. The most successful lines have been named NERICA varieties. There are currently 18 varieties suited for upland growth conditions (NERICA1 to NERICA18) and 60 varieties suited for lowland growth conditions (NERICA-L1 to

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**Box 15.1 The Participatory Varietal Selection Methodology**

Participatory varietal selection (PVS) aims to improve rice production through direct involvement of farmers, who play an active role in varietal selection, development, and dissemination. PVS is an adjunct to conventional breeding that markedly reduces the time taken for new varieties to reach farmers. In conventional breeding schemes, selection and testing procedures involve a series of multilocation trials over 8 to 12 years using a diminishing number of varieties. Through PVS, a large number of potentially interesting varieties reach farmers for evaluation in 5 years, and farmers have a major input into the selection of varieties to be released. By involving farmers in the varietal selection process, PVS aims to meet a diversity of demands for varieties, taking account of site-specificity for agronomic adaptation and selection criteria.

AfricaRice’s approach to PVS research involves a three-year program. In the first year, breeders identify centralized fields near villages and plant a rice garden trial of up to 60 upland varieties. The varieties range from traditional and popular *O. sativa* to NERICAs, African *O. glaberrimas*, and local varieties as checks. Male and female farmers are invited to visit the plot informally as often as possible. Groups of farmers formally evaluate the varieties at three key stages: maximum tillering (development of the plant leaves), maturity, and postharvest. At the first two stages, farmers compare agronomic traits. Each farmer’s varietal selection and the criteria for selection are recorded and later analyzed.

In the second year, each farmer receives as many as six of the varieties he or she selected in the first year to grow. PVS observers, including breeders and technicians from nongovernmental organizations and extension services, visit participating farmers’ fields to record seed performance and farmer evaluations of the selected varieties. At the end of the year, farmers evaluate threshability and palatability to provide an overall view of the strengths and weaknesses of the selected varieties. In the third year, farmers are asked to pay for seeds of the varieties they select. Willingness to pay provides evidence of the value farmers place on the seeds.

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*Source: Gridley and Sié 2008.*
NERICA-L60). Agronomic characteristics of these varieties vary widely, but they are generally high yielding and early maturing (a trait much appreciated by farmers), do not lodge or shatter, yield good grain quality, and are relatively resistant to the biotic and abiotic stresses of the continents harsh growth environment. Weed resistance of the NERICAs, especially the upland NERICAs, still needs improvement. (For details on the development and the characteristics of different NERICA varieties, see Somado, Guei, and Keya 2008; Wopereis and others 2008; and Kaneda 2007a, b, c, and d.)

**ADOPTION AND IMPACT OF NERICA VARIETIES IN SUB-SAHARAN AFRICA**

The first generation of interspecific progenies was introduced through participatory varietal selection trials in Côte d’Ivoire in 1996 and in other member countries of AfricaRice in 1997. NERICA1 and NERICA2 were officially released in 2001 in Côte d’Ivoire (Diagne 2006; Science Council 2007). NERICA varieties have now been introduced in more than 30 countries in Sub-Saharan Africa using PVS approaches, mostly thanks to the African Rice Initiative (ARI). By 2007, 17 upland NERICA varieties and 11 lowland NERICA varieties had been adopted. Where needed, ARI produced foundation seed to stimulate uptake of NERICA and other improved varieties. Seed production by ARI has increased steadily, from 2,733 tons in 2005 to 7,238 tons in 2007 and 13,108 tons in 2008 (Akintayo et al. 2009).

About 700,000 hectares in Sub-Saharan Africa were estimated to be under NERICA varieties as of 2009, covering an estimated 5 percent of the continent’s upland rice-growing areas. This level of penetration is impressive 8–10 years after release of the first varieties. The studies reviewed in this section describe the areas under NERICA varieties in selected countries, actual and potential rates of adoption among farmers, and the impact of NERICA varieties on rice productivity and the livelihoods of family farmers.

**Estimated area under NERICA**

Surveys conducted by national agricultural research systems provide estimates of the total area under NERICA varieties in different countries. Diagne et al. (2006) and Adegbola et al. (2006) estimate the total area under NERICA varieties at 51,000 hectares in Guinea in 2004 and 5,000 hectares in Benin in 2003. Based on its estimates of the quantities of seed produced and distributed to farmers, the National Food Reserve Agency (NFRA) of Nigeria reports 186,000 hectares under NERICA1 in Nigeria in 2007 (ARI 2008). The Uganda National Research Institute, citing a report of the Statistics Office of the Ministry of Agriculture in Uganda, estimates that 35,000 hectares were under NERICA4 in 2007 (ARI 2008).

Except in Guinea and Benin, where surveys were conducted (in 2003 in Guinea and in 2005 in Benin), the estimated areas under NERICA reported above by national agricultural research systems are based on quantities of seed produced and distributed to farmers. To meet the need to quantify uptake of NERICA and other improved varieties in a much more reliable manner, AfricaRice and partners are currently conducting surveys in many countries where NERICA is cultivated. Surveys conducted in 2009 by national agricultural research systems and national agricultural statistical services in 21 Sub-Saharan African countries provide more recent estimates for some countries (AfricaRice 2010). According to these data, the area under NERICA was about 142,391 hectares in Guinea and 244,293 hectares in Nigeria in 2009.11

**Adoption of NERICA varieties**

A 2009 study on adoption in Sub-Saharan African countries estimates actual rates of adoption of NERICA varieties (table 15.1).12 These rates illustrate a largely unrealized potential adoption rate if the full rice farming population of these countries could be exposed to NERICA varieties and provided access to seed.

Uptake of NERICA varieties was reportedly high in the Kaduna and Ekiti states of Nigeria (Spencer et al. 2006). About 30 percent of farmers in Ekiti cultivated NERICA1 in 2005; 42 percent of farmers in PVS villages and 19 percent in near–PVS villages did so in Kaduna.13 Adoption of NERICA1 appears to have continued during 2004 and 2005, despite the scaling down of PVS activities. About 35 percent

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**Table 15.1 Estimated Actual and Potential Rates of Adoption of NERICA Varieties in Selected African Countries (percent)**

<table>
<thead>
<tr>
<th>Country (year)</th>
<th>Rate of adoption</th>
<th>Potential rate of adoption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benin (2004)</td>
<td>19</td>
<td>47</td>
</tr>
<tr>
<td>Côte d’Ivoire (2000)</td>
<td>4</td>
<td>24</td>
</tr>
<tr>
<td>Guinea (2001)</td>
<td>20</td>
<td>61</td>
</tr>
<tr>
<td>The Gambia (2006)</td>
<td>40</td>
<td>87</td>
</tr>
</tbody>
</table>

Source: Diagne 2009.
of farmers in near-PVS villages in Ekiti and Kaduna had not heard about NERICA1, showing the potential for increase in adoption rates (Spencer et al. 2006). In 2005 an estimated 14 percent of farmers in PVS villages in Kaduna and 9 percent of farmers in near-PVS villages had adopted NERICA2.

The percentage of households that grew NERICA varieties in Uganda increased from 0.9 percent in 2002 to 2.9 percent in 2003 and 16.5 percent in 2004, according to Kijima, Otsuka, and Sserunkuuma (2008). They find that membership in a farmers group, formal education of the head of household, and the number of household members significantly increased the probability of adopting NERICA varieties as well as the scale of area planted to NERICA varieties. Land size per person had a negative effect on the share of land planted to NERICA varieties, suggesting that land-poor households tend to allocate a larger proportion of land to cultivation of NERICA varieties. This pattern is also observed among households headed by women, who are likely to be poorer. Poorer households in Uganda thus tend to allocate a larger proportion of their land to NERICA varieties, which may suggest that the adoption of NERICA has the potential to reduce poverty and improve income distribution as it increases rice yields.

Impact of NERICA varieties on productivity and livelihoods of farmers

NERICA rice varieties were developed with the aims of improving rice productivity, raising income, and reducing food insecurity of poor upland rice farmers (mostly women), who rarely use fertilizer, which they say they cannot afford. Empirical evidence from impact assessment studies conducted in West Africa points to a heterogeneous impact of NERICA adoption across and within countries (table 15.2). Impacts have been significantly positive in Benin and Gambia. In almost all countries, the impacts have generally been higher for women than for men (Diagne, Midingoyi, and Kinkingninhoun 2009).

In Benin farmers adopting NERICA enjoyed an additional yield gain of about 1 metric ton per hectare. The impact at the national level was very limited, however, because of the low diffusion of NERICA varieties in Benin (Adegbola et al. 2006).

Results from another analysis based on data from the 2004 season show that the impact of NERICA adoption is higher for women than for men (Agboh-Noameshie, Kinkingninhoun-Medagbe, and Diagne 2007). Female potential adopters have a surplus of production of 850 kilograms of paddy per hectare, compared with 517 kilograms of paddy per hectare for men; the potential net income gain from adopting NERICA is estimated at about $337 per hectare for women and $277 for men. Results in The Gambia indicate that an additional yield gain of 0.14 ton per hectare was achieved by rice farmers, most of them women, adopting NERICA varieties (Dibba 2010). Results from Côte d’Ivoire show that the impact is heterogeneous, with a sizable and statistically significant impact found for female farmers (0.7 ton per hectare) and a nonstatistically significant impact found for male farmers (Diagne 2006; Diagne, Midingoyi, and Kinkingninhoun 2009).

In Uganda NERICA had positive effects on productivity and allowed farmers to improve their yields (Kijima, Sserunkuuma, and Otsuka 2006; Kijima, Otsuka, and Sserunkuuma 2008; Bergman-Lodin 2005). According to Kijima, Sserunkuuma, and Otsuka (2006), the average yield of NERICA in Uganda was 2.2 tons per hectare—twice the average rice yield in Sub-Saharan Africa. They find large differences in yields between experienced (2.46 tons per hectare) and inexperienced (1.72 tons per hectare) households, indicating that experience matters in achieving high yields. Other yield determinants were rainfall and cropping patterns.

A few studies document the impact of adoption of NERICA varieties on household income and poverty. Most find that adoption increases household income and improves

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### Table 15.2 Yields and per Capita Income in Selected African Countries, by Gender

<table>
<thead>
<tr>
<th>Country (year)</th>
<th>Yield (tons/hectare)</th>
<th>Income ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benin (2004)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>0.26***</td>
<td>22***</td>
</tr>
<tr>
<td>Women</td>
<td>0.97***</td>
<td>38***</td>
</tr>
<tr>
<td>All</td>
<td>0.71***</td>
<td>25***</td>
</tr>
<tr>
<td>Côte d’Ivoire (2000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>0.44</td>
<td>—</td>
</tr>
<tr>
<td>Women</td>
<td>–0.45</td>
<td>—</td>
</tr>
<tr>
<td>All</td>
<td>^0.44</td>
<td>—</td>
</tr>
<tr>
<td>Men</td>
<td>0.18</td>
<td>4.6</td>
</tr>
<tr>
<td>Women</td>
<td>0.142***</td>
<td>10.6**</td>
</tr>
<tr>
<td>All</td>
<td>0.146***</td>
<td>10.2**</td>
</tr>
</tbody>
</table>


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* = Not available.
*** Significant at the 1 percent level; ** significant at the 5 percent level.
income distribution within households. In Uganda, for example, adoption of NERICA varieties has the potential to increase annual per capita income by $20 (12 percent of actual per capita income) and to reduce the incidence of poverty, measured by the headcount ratio, by 5 percentage points (from 54.3 percent to 49.1 percent) (Kijima, Otsuka, and Sserunkuuma 2008). The poverty gap index and the squared poverty gap index also declined following the introduction of NERICA, suggesting that adoption can increase incomes among the absolute poor in Uganda.

NERICA adoption has had a positive impact on household rice and total incomes in The Gambia (Glove 2009; Dibba 2010). Dibba (2010) finds that adoption of NERICA increases rice farmers’ daily income by about $0.34 on average (about 30 percent of the average daily income of adopters). Sogbossi (2008) identifies NERICA adoption as a key determinant in poverty reduction in Benin, where it reduced the probability of being poor by 13 percent.\(^\text{15}\) The impact of NERICA adoption was higher for women farmers (reduction in probability of being poor was 19 percent) than for men (reduction in probability of being poor was 6 percent). Findings from a study conducted in Nigeria indicate that adoption of NERICA increased total farm household gross income from rice by about $555 (about 46 percent of average gross income from rice), increasing farmer’s probability of escaping poverty (Dontsop et al. 2010).

These results suggest that NERICA can bring hope to millions of poor, small-scale farmers in Africa by reducing poverty and income inequality. Realization of this hope requires wider dissemination of NERICA, however, which can take place only if the seed bottlenecks and other production constraints examined in the next section are addressed.

**LESSONS LEARNED**

The use of the PVS approach allowed farmers to evaluate the new varieties in comparison with their own material. It enhanced capacity building and ownership of the NERICA varieties among farmers and national research and extension communities. PVS also reduced the time involved in the varietal release process in many countries.

Different partnerships and approaches were essential for NERICA adoption and seed production (box 15.2). In many countries the active involvement of government authorities at the highest level helped stimulate uptake. Major government initiatives on rice in Guinea, Mali, Nigeria, and Uganda focused on NERICA varieties. In Benin a private

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**Box 15.2 Successfully Disseminating NERICA Varieties in Burkina Faso, The Gambia, Guinea, and Uganda**

Partnerships with the National Agricultural Research Extension Systems, nongovernmental organizations, and farmer organizations, with support from donors and development partners, were key ingredients in scaling up the dissemination of NERICA varieties throughout Sub-Saharan Africa.\(^\text{a}\) Governments across the region also supported the dissemination of NERICA varieties through major rice development initiatives well before the 2008 food crisis.

**Burkina Faso**

Domestic rice production in Burkina Faso increased by an astonishing 241 percent in 2008 (Solidarité et Progrès 2008), partly as a result of the adoption of NERICA varieties. This remarkable achievement reflected the government’s response to the world food crisis in 2008. Emergency support facilitated farmers’ access to mineral fertilizer and quality seed of high-yielding rice varieties, including NERICA varieties.

**The Gambia**

NERICA varieties were introduced into The Gambia through PVS trials in 1998, initially in three villages and later more widely through farmers’ own channels and efforts by the National Agricultural Research Institute and the Department of Agricultural Services. The uptake of NERICA varieties continued through the African Rice Institute and NERICA dissemination project funded by the African Development Bank in 2004. Even the head of state was growing NERICA varieties on his own land and encouraging farmers to grow these varieties. According to FAO data, from 2001 to 2007, the rice-growing area was relatively constant, at about 17,000 hectares. A doubling to 34,000 hectares occurred (continued next page)
in 2008, partly as a result of the enthusiasm generated by NERICA varieties, the support of the government, and the efforts of researchers and technicians. NERICA varieties are now cultivated in all six agricultural regions of the country. Introduction of the varieties has brought hope for increased rice productivity and poverty reduction.

**Guinea**

The first interspecific lines were introduced in Guinea in 1997 by the Institut de Recherche Agronomique de Guinée (IRAG) and the Service National de la Promotion Rurale et de la Vulgarisation (SNPRV) through an intensive program to introduce new upland rice varieties. NERICA varieties subsequently experienced a very rapid spread in the regions of Upper Guinea and Forest Guinea after only two years of experimental testing and PVS (Camara et al. 2002; Diagne 2006). A study by researchers from AfricaRice, IRAG, and SNPRV in the four regions of Guinea estimates the area under NERICA varieties at 51,000 hectares in 2003, slightly less than 10 percent of the 525,000 hectares used for rice production according to Food and Agriculture Organization (FAO) statistics (FAOSTAT 2010)—a remarkable achievement in a relatively short time. In 2007 the area under NERICA varieties in Guinea was estimated at 82,930 hectares, 12 percent of the total rice area (ARI 2008). Estimates from the nationwide survey show that the area under NERICA has grown significantly since 2007 to 142,391 hectares, representing about 18 percent of the total rice area in Guinea (AfricaRice 2010).

Several factors explain the success of NERICA varieties in Guinea. First, NERICA varieties appeared when Guinea was experiencing a period of prolonged drought that had pushed the Guinean government to seek assistance from AfricaRice to put at farmers’ disposal short-season varieties that could better cope with drought (Diagne 2006). NERICA varieties corresponded well to what was needed. Second, Guinean farmers were very receptive to experimenting with new varieties in their fields. Third, an effective partnership between national and international institutions greatly contributed to the rapid adoption of the new rice varieties. The World Bank funded the program through its Special Program for Agricultural Research in Africa (SPAR). IRAG and SNPRV worked together to select the most appropriate testing sites and methods of introduction, joining hands with an international nongovernmental organization, Sasakawa Global 2000. This cooperation facilitated access to inputs for farmers involved in the trials. AfricaRice staff provided training to IRAG and SNPRV scientists and technicians in the conduct of the PVS trials and seed production throughout the duration of the program (Kaneda 2007d; Diagne 2006).

**Uganda**

Rice farming is relatively marginal in East Africa, especially in Uganda. Before 2002 rice farming was practiced mostly as a cash crop by only a few farmers on a very small upland area and in very few small irrigated schemes. Research support had been abandoned in the 1970s, and rice yields had gradually declined to about 0.4 ton per hectare in 2002. The introduction of NERICA varieties enabled farmers to attain yields of up to 3 tons per hectare on fertile land in Uganda.

By 2002 NERICA varieties were being cultivated in many parts of Uganda. Rice acreage increased sixfold in the six years following the release of the new varieties, from 6,000 hectares in 2002 to 40,000 hectares in 2008, and the number of rice growers rose from 4,000 in 2004 to 35,000 in 2007 (Akintayo et al. 2009). Uganda reduced its rice importation from 60,000 tons in 2005 to 35,000 tons in 2007—an almost 50 percent reduction in rice imports, leading to savings of about $30 million (Akintayo and others 2009). Several factors explain the rapid uptake in Uganda. The great interest shown by the National Institute of Agricultural Research for the new varieties at the time of revitalizing its rice program and the dynamism of Sasakawa Global 2000 played very important roles in the introduction and diffusion of NERICA varieties. The interest and dynamism of the private sector was essential in producing and marketing seed of NERICA varieties, as was the active involvement of the highest political authorities of the country, particularly Uganda’s vice president (Akintayo et al. 2009).

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a. Donors included the African Development Bank, the Food and Agricultural Organization, the Government of Japan, the International Development Research Centre, the International Fund for Agricultural Development, the Rockefeller Foundation, the United Nations Development Programme, the U.S. Agency for International Development, and the World Bank.
entrepreneur was instrumental in the diffusion of NERICA varieties, paying for demonstration plots across the country and promoting seed production (Akintayo et al. 2009).

The ARI–coordinated NERICA dissemination project funded by the African Development Bank and numerous smaller projects run by the Japan International Cooperation Agency, FAO, and many nongovernmental organizations (NGOs) greatly accelerated the uptake of NERICA varieties across Sub-Saharan Africa (map 15.1). Despite these efforts, seed production remains a major bottleneck, especially in West and Central Africa, where many farmers lack access to improved rice varieties. In many countries, national seed regulatory bodies do not exist or are dysfunctional. Functioning bodies are essential to estimate and meet the demand for rice seed for different ecosystems and consumer preferences. Incentives should be provided to small-scale enterprises to develop viable seed businesses.

The data on potential adoption rates of NERICA varieties illustrate its tremendous potential to reach still more farmers. The constraints to doing so are numerous and vary from country to country. One major factor is the desperate lack of capacity at all levels in the rice value chain, especially the neglect of Africa's rice research capacity. Only about 250–275 researchers (including only about 15 women) are involved to some extent in rice research in AfricaRice member states, according to a 2008 survey—and most of them work on many other crops and spend only a fraction of their time on rice. Egypt alone accounts for the lion's share of this research pool, with 50 highly qualified researchers working full time on rice, including 12 rice breeders. In comparison, Nigeria has only 2 rice breeders.

Other issues include lack of access to seed, fertilizer, and credit and inadequate rice production, processing, distribution, and marketing infrastructure. These factors need to be identified, and relevant actions taken to develop the rice sector. An integrated approach from seed to plate is needed.

Africa has tremendous potential to expand the area under rice cropping, especially in the rainfed lowland ecosystem. It has been estimated that 200 million hectares of rainfed lowland area could be developed for rice across the continent. If just 1 percent of this land were allocated to growing rice and the average yield was just 3 tons per hectare, Africa would produce another 6 million tons of rice a year, making a major dent in the 10 million tons of rice it imports. The lowlands offer great potential for the sustainable expansion, intensification, and diversification of rice-based systems. Given this potential, the lowland NERICA varieties and their successors are expected to have an even greater impact than the upland NERICA varieties.

Map 15.1 Areas of Sub-Saharan Africa Producing NERICA Varieties, 2005 and 2006

CONCLUSIONS

As a result of the increase in rice consumption across Sub-Saharan Africa, the continent accounted for 30 percent of world rice imports in 2009, costing African economies an estimated $4 billion. Relying on the world market to feed Africa’s rice consumers is a risky and unsustainable strategy. Encouraging the development of Africa’s rice sector is crucial for food security. The sector could also serve as an engine for economic growth (IFPRI 2006).

Development of Africa’s rice sector will require an integrated seed to plate value chain approach. Much work is still needed to identify the varieties that respond to consumer demand and grow well in the various ecosystems in which rice is grown in Africa, under both current and future climate scenarios. Much greater input in varietal development is needed at the national level, and greater capacity in rice breeding is needed across the continent.

NERICA varieties have shown great potential in both upland and lowland ecosystems in Africa, where they currently cover more than 700,000 hectares. Women farmers in particular have profited from NERICA varieties. More effort is needed to ensure that larger numbers of rice farmers, including farmers who have never seen a new rice variety, can profit from these new varieties, especially in rainfed ecologies.

AfricaRice is already working on new varieties that will replace the first generation of NERICA varieties, in close collaboration with national agricultural research institutes, the International Rice Research Institute, and other international research institutes in Japan, Europe, and the United States. These efforts, together with a better definition of farmers’ needs and consumer demands, are expected to lead to the development of varieties that will eventually outperform the current generation of NERICA varieties.

AfricaRice is an active member of the Coalition of African Rice Development, an initiative of the Japan International Cooperation Agency and the Alliance for a Green Revolution in Africa, which aims to double rice production in Sub-Saharan Africa between 2008 and 2018. Such partnerships and commitment at the national and regional level to hire, train, and retain new staff in rice research and invest in rice production, storage, processing, and distribution capacity will be instrumental in boosting Africa’s rice sector.
Table 15.A1 Performance of NERICA Progenies and Their Parents under Various Conditions

<table>
<thead>
<tr>
<th>Item</th>
<th>Yield under high- and low-input conditions</th>
<th>Yield under drought- and nondrought-prone sites</th>
<th>Yield under acid and nonacid soil sites</th>
<th>Susceptibility to gall midge attack</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low input</td>
<td>High input</td>
<td>Drought</td>
<td>Nondrought</td>
</tr>
<tr>
<td>NERICA progeny line</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample size</td>
<td>19</td>
<td>19</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Mean (across replications and lines)</td>
<td>1.16</td>
<td>3.07</td>
<td>1.62</td>
<td>2.05</td>
</tr>
<tr>
<td>Standard deviation (across lines)</td>
<td>0.16</td>
<td>0.50</td>
<td>0.39</td>
<td>0.36</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.91</td>
<td>1.70</td>
<td>1.08</td>
<td>1.49</td>
</tr>
<tr>
<td>Maximum</td>
<td>1.47</td>
<td>3.86</td>
<td>2.27</td>
<td>2.66</td>
</tr>
<tr>
<td>Sativa parent (WAB56-104)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean value (across replications)</td>
<td>0.90</td>
<td>3.26</td>
<td>1.19</td>
<td>1.96</td>
</tr>
<tr>
<td>T-test for equality with mean of NERICA lines</td>
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<tr>
<td>Mean value (across replications)</td>
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<td>1.24</td>
<td>0.86</td>
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<tr>
<td>T-test for equality with mean of NERICA lines</td>
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<tr>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Sativa tolerant check</td>
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<td></td>
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<tr>
<td>Mean value (across replications)</td>
<td></td>
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<tr>
<td>T-test for equality with mean of NERICA lines</td>
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<tr>
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<tr>
<td>Sativa susceptible check</td>
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<tr>
<td>Mean value (across replications)</td>
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<td>T-test for equality with mean of NERICA lines</td>
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<tr>
<td>p-value</td>
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Source: Authors, based on data from experiment in 1999 at AfricaRice headquarters (in M’bé) and at two of its on-farm research sites (in Man and Korhogo). The trials used a randomized complete block design with three replicates at each site: the NERICA progenies, their two sativa and glaberrima parents (WAB56 104 and CG14), and a select set of sativa checks, which varied across the trials. The set of NERICA progenies also differed across trials.

a. Yield data are mean values for two sites (M’bé and Man) from a 1999 randomized complete block design trial with three replicates at each site.
b. Moroberekan, a local sativa variety commonly used as check for drought.
c. IR20, an improved sativa variety used as check for drought.
Figure 15.A1  Performance of NERICA Progenies under Low and High Input Conditions and Major Stresses in Upland Rice Ecosystems

Source: Authors, based on data from experiment in 1999 at AfricaRice headquarters (in M’bé) and at two of its on-farm research sites (in Man and Korhogo). The trials used a randomized complete block design with three replicates at each site: the NERICA progenies, their two sativa and glaberrima parents (WAB56 104 and CG14), and a select set of sativa checks, which varied across the trials. The set of NERICA progenies also differed across trials.

Note: Sample sizes are 19 for panel a, 16 for panel b, 25 for panel c, and 100 for panel d.
NOTES

1. The role of technological innovation in raising agricultural productivity and fostering overall agricultural development is documented in the World Bank’s 2008 World Development Report.

2. The Africa Rice Center—AfricaRice for short—is the new official name, adopted in September 2009, for the organization previously known as the West Africa Rice Development Association (WARDA). This intergovernmental association of African countries is one of the 15 international agricultural research centers supported by the Consultative Group on International Agricultural Research (CGIAR). The center was created in 1971 by 11 African countries. With the continuing expansion of its activities into Central, East, and North Africa, the Council of Ministers passed a resolution at their 27th meeting, held in Lomé, Togo, in September 2009, to change its name from WARDA to AfricaRice. Today its membership comprises 24 countries: Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Côte d’Ivoire, Democratic Republic of Congo, Arab Republic of Egypt, Gabon, The Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Madagascar, Mali, Mauritania, Niger, Nigeria, Republic of Congo, Senegal, Sierra Leone, Togo, and Uganda.

3. The importance of the development of NERICA varieties has been widely recognized. The Consultative Group on International Agricultural Research (CGIAR) presented the King Baudouin Award to the Africa Rice Center (then WARDA) in 2000 for the development of NERICA varieties. In 2004 the center’s Dr. Monty Jones became the first African to receive the World Food Prize, for his contribution to the development of the family of NERICA rice varieties suitable for upland growth conditions. Dr. Moussa SiÈ, a senior rice breeder at AfricaRice, was awarded the prestigious International Koshihikari Rice Prize of Japan, in recognition of his leadership in developing the family of NERICA rice varieties suitable for lowland growth conditions.

4. Rice is generally associated with Asia, but it is also an integral part of the history and culture of Africa, where it has been grown for more than 3,000 years. Oryza glaberrima was grown largely in the central delta of the Niger River and in the Higher Gambia and the Casamance region of what is now Senegal (Carney 1998; Poteres 1962, cited in Linares 2002). Oryza glaberrima was the only rice species grown in West Africa until the 16th century, when the Portuguese introduced the Asian species Oryza sativa in the West African coastal regions (Linares 2002). Over the years, O. sativa gradually replaced O. glaberrima, which has some unfavorable characteristics. Farmers who still grow O. glaberrima do so mostly for social or religious reasons, for its culinary and nutritional qualities, or because it is better adapted to their agroclimatic environments.

5. Seventy percent of the production increase came from land expansion, with just 30 percent attributable to productivity enhancement.

6. Lodging is the process in which rice plants fall over at, or just before, maturity; shattering is the process in which plants’ panicles scatter their seeds on the ground at maturity.

7. NERICA rice varieties are interspecific but not genetically modified.

8. AfricaRice has five on-farm research sites in Côte d’Ivoire, known as “key sites.” The sites—selected in the early 1990s, when AfricaRice moved its headquarters to Côte d’Ivoire from Liberia—were chosen to cover all nine rice ecologies and the main rice-producing regions in the forest and savanna agroecological zones of Côte d’Ivoire and to be representative of almost all of the rice-growing ecologies in West Africa.

9. NERICA varieties have retained only about 5–10 percent of the genome of the African parent, because of backcrosses to the O. sativa parent. They are also based on crosses between only a handful of O. sativa and O. glaberrima accessions. AfricaRice breeders have since developed “bridge varieties” that show full fertility when crossed with O. glaberrima, potentially allowing the full exploitation of all 2,300 accessions of the O. glaberrima species in the gene bank of AfricaRice and a much greater retention of the O. glaberrima genome. Molecular assisted breeding is also becoming a routine tool, accelerating varietal development.

10. ARI was established in 2002 by AfricaRice and key donor partners, including the African Development Bank, the government of Japan, the Rockefeller Foundation, and the United Nations Development Programme, in order to facilitate the dissemination of NERICA varieties and other improved varieties in Sub-Saharan Africa. This network of rice research and extension organizations and private sector partners plays an important role in making quality rice seed available. This role is crucial, as seed availability is one of the weakest links in the rice value chain in Africa.

11. Data from these national surveys, which are still being processed, are expected to provide more accurate estimates of the total area under NERICA in Sub-Saharan Africa. Preliminary figures from these surveys and other secondary sources suggest that about 700,000 hectares was under NERICA in Sub-Saharan Africa in 2009.

12. The potential adoption rate estimated here is the adoption rate when the entire population of rice farmers is made aware of the existence of the NERICA varieties (Diagne and Demont 2007). Observed adoption rates are lower than these estimated potential adoption rates because many farmers simply lack awareness of the NERICA’s existence.

13. PVS villages are villages in which NERICA varieties were tested and evaluated by farmers through participatory varietal selection (PVS) trials. The nearby villages are villages
not hosting PVS trials but within 2–5 kilometers radius of the selected PVS-hosting villages.

14. With women making up 93 percent of sample farmers in The Gambia (sample includes 39 men and 532 women), it is not surprising that the average for the whole sample and the sample for women are almost the same. The average gain for men is not significant. Although seemingly small, the 0.14 ton per hectare average gain from NERICA adoption is statistically significant and represents about 15 percent of the average rice yield obtained by farmers (just under 1 ton per hectare).

15. The poor are defined using the income poverty line in Benin, estimated at CFA 51,413 a year (about $100) in rural areas and CFA 91,709 a year (about $180) in urban areas (Sogbossi 2008).

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