Chapter 5
Rice Production in Africa

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5.1 Introduction

Due to high demand, rice production has increased continuously over several decades, from a growth rate of 1.76 % in 1991–2001 to 3.96 % during 2002–2013. This rapid growth rate has made rice the fastest emerging cereal crop in sub-Saharan Africa (SSA) and the second major source of energy on the continent (Seck et al. 2012). However, currently rice production is lower than the demand that is driven by rapid population growth and the preference by urban dwellers for rice as a convenient and easy-to-cook cereal compared to traditional dishes (Seck et al. 2013). Rice is thus one of the most valued food crops on the continent and a very important political crop, shortage or price fluctuation of which can result in civil unrest, as witnessed during the rice crisis in 2007–2008 (Seck et al. 2013).

Although Africa has vast natural resources and the potential to produce enough food for its 900 million people, only 60 % of its demand for rice is produced locally, the rest being imported. Analysts indicate that the current dependence on the

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B.S. Chauhan et al. (eds.), *Rice Production Worldwide*,
DOI 10.1007/978-3-319-47516-5_5

international market is not sustainable because supply is unreliable and rice prices fluctuate (Wopereis et al. 2013). To overcome this chronic food insecurity, African policy makers have developed ambitious plans for achieving food self-sufficiency and to turn rice into a profitable venture for farmers and other stakeholders. To realize the plans, a wide range of research-for-development activities are being undertaken in partnership with various institutions within and outside of Africa (Tollens et al. 2013).

This chapter provides historical highlights on rice in Africa, its production systems, challenges, and current major activities toward self-sufficiency, as well as the role of the Africa Rice Center (AfricaRice) as a center of excellence for rice research in Africa.

5.2 History and Importance of Rice in Africa

5.2.1 History

Through thousands of years of rice cultivation experience, African farmers have generated diverse rice genetic resources, which are well adapted to diverse agroecologies and multiple biotic and abiotic stresses on the continent (Sanni et al. 2013). African rice, *Oryza glaberrima* Steud, is one of the two cultivated species, and was independently domesticated from its wild ancestor *O. barthii* in the Niger River delta about 3000 years ago (Jones et al. 1997). Since then, it has spread to two secondary centers of domestication, one along the coast in The Gambia, Senegal, and Guinea-Bissau and the second in the Guinea forest between Sierra Leone and the western part of Côte d'Ivoire (Portères 1962, 1976). Molecular investigations through isozyme studies followed by simple sequence repeat (SSR) and single nucleotide polymorphism (SNP) confirmed the uniqueness of African rice and its close genetic relationship to *O. barthii* (Second 1982; Semon et al. 2005). In its evolution as a cultivated crop, *O. glaberrima* has shaped the diet and culture of Africa region, and it even helped Africa to overcome famine in 1203 (GRiSP 2015). Highly sophisticated rice cultivation technologies and cultural practices existed in West Africa, with a variety of production systems used in different environments and landscapes, including the construction of elaborate canals and dikes in coastal swamps (Carney 2001). This indigenous rice production knowledge is believed to have been transferred to North America, through the slave trade that transported people from West Africa to the Americas. This technology transfer seems to have contributed to the economy as well as food culture of Carolina. For instance, a rice recipe called Hoppin' John or red rice that is popular in Georgia and South Carolina came from the West African recipe called Jollo Rice (Carney 2001).

However, after the introduction of Asian rice *O. sativa* into Africa through East Africa by traders from India in the early 1500s (Harlan and Stemler 1976; Ng et al. 1991), *O. sativa* has spread westward (Portères 1962) and the cultivation of *O. glaberrima* has declined. *O. sativa* is now widely cultivated on the continent. Although the two cultivated species have some traits in common, they are significantly different

Table 5.1 Differentiating characteristics of cultivated rice species and their wild progenitors

Origin	Species	Distribution	Biological type	Reproduction
Asian				
Cultivated species	*Oryza sativa* (with two sub spp. indica and japonica)	Asia	Intermediate	Self-pollinated plant (often) and intermediate
Wild species	*Oryza rufipogon*	Asia, Australia, and America	Annual Intermediate	Self-pollinated and cross-pollinated plant, intermediate, and vegetative reproduction
African				
Cultivated species	*Oryza glaberrima*	Africa	Annual	Self-pollinated plant
Wild species	*Oryza barthii*	Africa	Annual	Self-pollinated plant
	Oryza longistaminata	Africa	Perennial	Cross-pollinated plant and vegetative reproduction

Adapted from Agnoun et al. (2012) with permission

from each other (Linares 2002; Agnoun et al. 2012) (Table 5.1). Through thousands of years of production in the region, *O. glaberrima* is well adapted for cultivation in West Africa and possesses important traits such as tolerance of biotic and abiotic stresses; on the other hand, *O. sativa* produces much higher yields and therefore has higher commercial value. Rice breeders have been exploiting the stress tolerance of *O. glaberrima* to improve *O. sativa* for different stress tolerance traits while maintaining high yields (Futakuchi et al. 2012).

The collection, conservation, and utilization of genetic diversity of the indigenous cultivated and wild rice species in Africa is the responsibility of AfricaRice and the genetic resources are kept in trust for humanity under the auspices of the Food and Agriculture Organization of the United Nations (FAO). The AfricaRice gene bank currently has more than 20,000 accessions of *O. sativa* and *O. glaberrima* as well as wild species (*O. longisataminata, O. barthii,* and *O. stapfii*) (Sanni et al. 2013). Using these genetic resources, African scientists have generated "New Rice for Africa" (NERICA) varieties, which combine the high-yielding traits of *O. sativa* with the stress-adaptive traits of African rice, and ushered in the green revolution in Africa (Sie et al. 2012). The genome of *O. glaberrima* has been sequenced through collaborative effort, thus providing new opportunities for quick and efficient exploitation of the genome to develop climate-resilient varieties (Wang et al. 2011).

The ever increasing demand for rice is dynamically shaping the rice production system, intensification, and expansion. Consequently, rice is now grown in 40 African countries on nearly 10 million ha of land (AfricaRice 2011; Diagne et al. 2013) (Fig. 5.1). The five major rice producing countries are Nigeria (1,895,697 ha), Madagascar (1,183,614 ha), Guinea (1,005,822 ha), Côte d'Ivoire (968,271 ha), and Tanzania (942,438) (Diagne et al. 2013). Many of the rice growing countries have favorable policies and national strategic rice development plans, with a keen focus

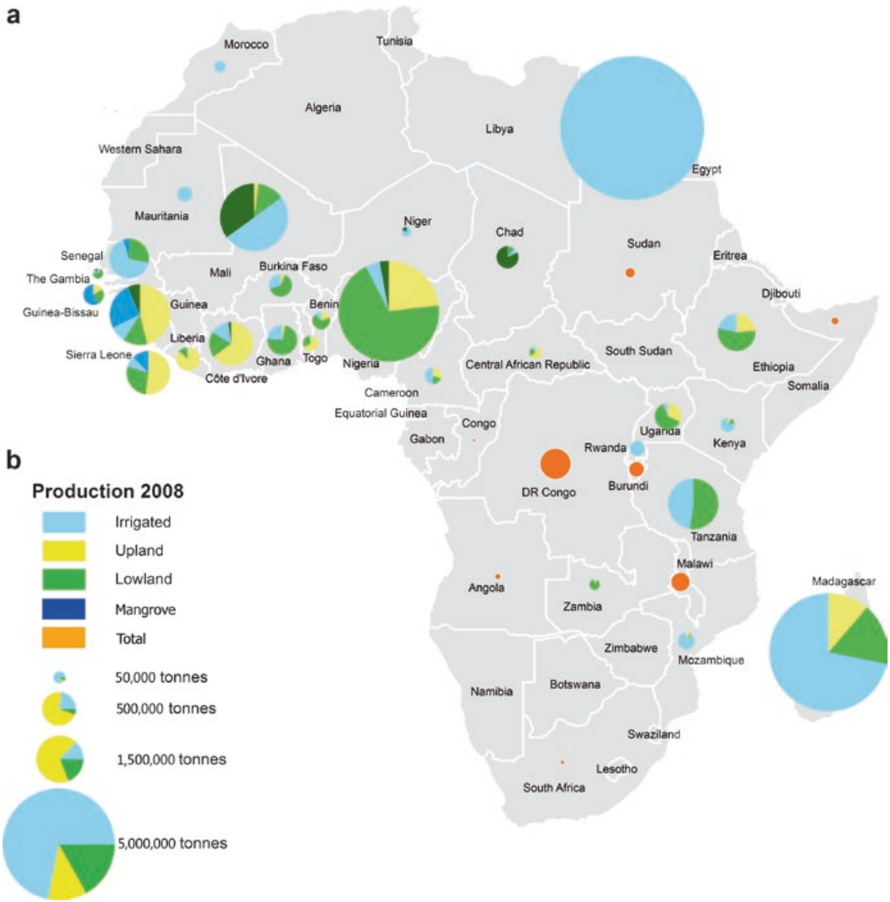

Fig. 5.1 Paddy rice production in Africa (Reprint from (AfricaRice 2011) with permission)

on satisfying demand with local production and benefiting farmers and other stakeholders along the whole value chain (JICA 2009).

5.2.2 Current Trends in Rice Production and Consumption

Rice production and consumption in SSA have progressed at variable rates. From 1961 to 2006, annual rice production growth rate was 3.18 % compared to 2.9 % for annual increase in demand (AfricaRice 2008). Then the increase in production was attained mainly from area expansion. However, from 2007 to 2012, an unprecedented production growth rate of 8.4 % per year occurred. This leap occurred after the rice crisis of 2007–2008 that triggered positive interventions by governments to boost local production—70 % of the increase was due to higher yields per unit area and only 29 % to area expansion. The annual yield increase that is equivalent to 108 kg/ha between 2007 and 2012 is comparable to the one obtained in Asia during the green revolution (Seck et al. 2013). However, despite these developments, the overall rice demand in Africa has outstripped local production and 40 % of the rice consumed is imported. Consumption rate is expected to increase by 130 % in 2035 compared to 2010 (Seck et al. 2013), which urges African rice producers to increase their production capacity drastically to meet the ever increasing demand with local produce.

5.3 Major Rice Production Ecologies in Africa

In Africa, rice is grown in rainfed upland and aquatic environments. Based on topography, water management and genetic adaptability, the aquatic environment is subdivided into four major ecologies: rainfed lowland, deep water, mangrove, and irrigated ecology (Sie et al. 2012). High elevation is considered as a special ecology due to its specific requirement for cold-tolerant varieties (AfricaRice 2011).

5.3.1 Rainfed Upland

Rainfed upland is the second largest rice production ecology in sub-Saharan Africa (SSA) (Diagne et al. 2013) (Table 5.2). In this ecology, rice is grown without soil surface flooding. Most farmers in this ecology are resource poor and cannot afford agricultural inputs. Consequently, they practice the "slash and burn" system as well as permanent rice cultivation without a fallow period. Forest areas are cleared to exploit the natural fertility of the forest soil. However, since no measure is taken to improve the soil fertility and due to weed pressure, rice yields decline drastically after one season and farmers have to constantly clear new forest areas for cultivation, a system called the "shifting cultivation" (Balasubramanian et al. 2007). In sloppy areas, where rice is grown continuously, it is intercropped with other locally adopted crops as a risk management strategy in case the rice crop fails due to drought or poor soil fertility.

Land preparation is carried out manually with a hand-hoe or with the help of Oxen, to be followed by broadcasting or direct seeding 80 kg of seed per hectare. Weeding is done one or two times per season depending on the availability of family labor. The major weed species encountered are *Cyperus* spp., *Imperata cylindrical, Chromolaena odorata*, *Digitaria horizontalis*, *Euphorbia heterophylla, Ageratum conyzoides*, and *Striga* spp. (Rodenburg et al. 2009).

The major biotic stresses are blast, African rice gall midge (AfRGM), stem borers, bacterial leaf blight (BLB), and rice yellow mottle virus (RYMV) (Table 5.2). Despite huge losses caused by insects and diseases, SSA farmers rarely apply appropriate management techniques. They mostly depend on the innate potential of the variety to resist all biotic constraints, while a few control blast with fungicides

Table 5.2 Rice production ecologies in Africa and production potential and yield limiting factors

Rice production ecologies	Shared production area (%)	Yield: actual/ potential (t/ha)	Yield-limiting factors		
			Abiotic factors	Biotic factors	Input use
Rainfed upland	30	1.2/2–5	P and N deficiency, acidity, Al toxicity, drought, erosion, poor soil fertility	Weeds, termites, stem borers, AfRGM Disease (blast, BLB, RYMV), birds, nematodes, and rodents	Very low
Aquatic					
Rainfed lowland	33	1.9/3–6	Water control, N and P deficiency, Fe toxicity	Weeds, termites, stem borers, AfRGM Disease (blast, BLB, RYMV), birds	Low
Mangrove and deep water	4	<1/2–4	Acid sulfate, salinity, Fe toxicity, excess water	Insect pests, diseases, birds	Very low
Irrigated	26	1.9–3.7/5–12	N deficiency, salinity and alkalinity, extreme temperatures	Weeds, stem borers, AfRGM Disease (blast, BLB, RYMV), birds	High
High elevation (*upland and lowland)*	7	1.2/2–6	Cold, Fe toxicity, P and N deficiency, excess water	Weeds, stem borers Disease (blast, BLB, RYMV), birds	Low

Updated from Diagne et al. (2013), Dramé et al. (2013), Haefele and Wopereis (2004)

and by burning stubbles and weeds after harvest to control viruses. In general rice is harvestedand threshed manually, although a few farmers thresh with semiautomatic pedal-operated machines.

Farmers in SSA often experience crop failure as a result of poor cultural practices (such as low inputs, suboptimal crop management practices, and inadequate weed management) and lack of climate resilient varieties. Major constraints per ecology are presented in Table 5.2.

Upland varieties (such as Dourado Precoce and Iguape Cateto), were initially introduced from Brazil but were later replaced by IRAT (Institute for Research in Tropical Agriculture, France) varieties (such as IRAT 10, IRAT 144, and IRAT 13) and recently by NERICA (New Rice for Africa) varieties. Yields under current crop management practices by farmers average 1.2 ton/ha (Dramé et al. 2013) compared to 5 ton/ha with improved NERICA varieties, indicating a huge gap that needs to be closed. Côte d'Ivoire has the largest upland area in Africa (615,325 ha) followed by Nigeria (557,256 ha) and Guinea (532,329 ha) (Diagne et al. 2013). The major genotypes found in this ecology are *O. sativa* tropical japonica type and *O. glaberrima.*

5.3.2 Aquatic Ecology

In SSA about 130 million ha (Diagne et al. 2013) is considered to be under the aquatic ecology, but less than 5% is cultivated with rice (Balasubramanian et al. 2007). Lowland varieties were introduced mainly from Asia—the earliest ones were photoperiod sensitive and susceptible to biotic and abiotic stresses. Some of these accessions with indica background were adopted by farmers due to their consumer preference (e.g., Gambiaka in West Africa, Supa in East Africa, Makalaoka in Southern Africa, particularly Madagascar). They have long grains, good eating and cooking qualities and aroma but give low yields. Although improved versions have been developed through conventional or mutation breeding techniques and released by National Agricultural Research Systems (NARS) institutions, the gap between the potential of the germplasm and actual farmers' yields is still very large.

5.3.2.1 Rainfed Lowland

The rainfed lowland ecology, which comprises gentle slopes and inland valleys, is the largest ecology, covering 33 % of the whole rice production area, and relies on rainfall and ground water (Diagne et al. 2013). Fields could be bunded or unbunded, but there is no water control, with droughts and floods being potential problems Hatibu et al. 2000. Rice is broadcasted or transplanted and one rice crop is cultivated per year followed by vegetables where residual moisture is available. The great potential for rice production in this ecology is highly compromised by biotic and abiotic constraints, including weeds, insect pests (such as stem borers, AfRGM, and rice sucking bugs), and diseases (rice blast, brown spot of rice, and RYMV) (Table 5.2).

Nigeria has the largest rainfed lowland area (1,039,935 ha) followed by Tanzania (677,806 ha) and Madagascar (322,688 ha) (Harlan and Stemler 1976). Since most lowland rice farmers apply minimal inputs and suboptimal crop management practices, the average yield of 1.9 ton/ha is much lower than the potential of up to 6.0 ton/ha (Dramé et al. 2013). Both *O. sativa* indica and *O. glaberrima* are grown in this ecology, of which deep water and mangrove swamps are subdivisions.

Deep Water Ecology

Deep water ecology is found in the low-lying wetlands of Madagascar and the poorly drained inland valleys of Chad, Guinea, Mali, Niger, and Nigeria. Deep water rice, also called floating rice, is sown before the floodwaters rise and flowers just before maximum water depth is reached. Deep water rice varieties that can elongate to a maximum water depth of 1.0 m or more and float are suitable for this ecology. They can elongate at a rate of 2–3 cm/day (Catling 1992) and up to 6 m high and produce adventitious roots to extract nutrients directly from the water. The deep water ecology is currently shrinking due to the expansion of dam construction that restricts the flow of water. Due to the stresses in this ecology, which include drought, stem borers, and weeds, the average yield is about 0.9 ton/ha (Lancon 2002).

Mangrove Ecology

Large tracts of rice production areas in SSA experience excess flooding, tidal submergence, saltwater intrusion, salinity, and acid sulfate soils. Mangrove swamp rice is found mostly in Guinea Bissau, The Gambia, and Guinea Conakry (Defoer et al. 2007). In this ecology, rice can be grown during the rainy season, when freshwater floods create a salt-free period of 4–6 months. Yields are below 1 ton/ha due to salinity, crabs, and other stresses (Lancon 2002). The major constraints for rice cultivation in both mangrove and deep water ecologies are low input management followed by insect pests and diseases (Table 5.2).

5.3.2.2 Irrigated Lowland

Irrigated rice is grown in bunded fields with assured irrigation for one or more crops per year. The irrigated ecology is subdivided into irrigated wet season ecology and irrigated dry season ecology, based on the source of water (IRRI 2002). This ecology is relatively new to Africa and only 26% of the aquatic area is irrigated (Diagne et al. 2013). Rice is produced under irrigation in the Sahel, humid forest, and savanna zones and at high elevations. This ecology requires substantial investment but yields good returns on investment. The major water sources are dams, diversion from rivers, or wells (Saito et al. 2013).

In SSA, Madagascar has the largest irrigated area (782,487 ha) followed by Egypt (518,320 ha) and Mali (335,269 ha) (Diagne et al. 2013). In Madagascar, irrigated rice is produced in both wet and dry seasons in well leveled terraces with water from small earth dams on streams and small rivers. Irrigation schemes are smaller in the humid forest and savanna zones than in the Sahel - rainfall is the principal source of water and water control is difficult. Consequently, irrigation is used as a supplement to protect the crop during dry spells in the cropping season. Yields are generally lower than in the Sahel due to less solar radiation, poor soil fertility, pests and diseases (Balasubramanian et al. 2007).

Land preparation is predominantly by manual labor although animal-drawn tools or hand tractors are also used wherever possible. Large tractors are used only in large public or privately owned fields. Direct seeding is a common practice in the Sahelian zone while transplanting is practiced in the other zones. Seed is sown at

30-40 kg/ha either in nurseries or by direct sowing. Farmers widely use organic manure and compost to improve the soil, while few progressive farmers apply diammonium phosphate (DAP) as basal fertilizer, urea as top dressing, and other compound fertilizers, such as NPK.

Weeds are less diverse in the aquatic than in the upland ecology. The most common weed species are *Sphenoclea zeylanica, Cyperus difformis, Echinochloa spp., Oryza spp* (wild and weedy rices), and *Rhamphicarpa fistulosa* (Rodenburg et al. 2009). Manual weeding is done two to three times per season, depending on labor availability. Mechanical weeders are currently being popularized by AfricaRice and its development partners. Chemical herbicides are used by a few farmers, especially in large farms.

Rice is mostly harvested manually and less than 1% is harvested with machines. Similarly, 80% of the threshing is done manually, sometimes with the help of oxen and tractors, while 15% is with semi-automatic pedal-operated machines; motorized threshers such as Votex and ASI-threshers (developed by AfricaRice in Senegal) are used in less than 5% of cases (AfricaRice 2012; Rickman et al. 2013).

The major genotype cultivated in this ecology is *O. sativa* indica type. In the Sahel as a result of high solar radiation, good water management, low disease pressure, and other favorable conditions, average yields in the Sahel are high – up to 9 t/ha (especially during the dry season) and up to 12 t/ha has been achieved with good agricultural practices (Haefele and Wopereis 2004). Nevertheless, extreme yield fluctuations have been observed due to; sub-optimal crop management practices; poor maintenance of irrigation facilities; extreme temperatures and other factors that are not conducive for rice production. As a result, double cropping occurs in only 10% of the area (Wopereis et al. 2013).

5.3.3 High Elevation

About 7 % of Africa's rice production area occurs in the high elevation zone, above 1200 m above sea level (MASL) (Saito et al. 2013). In the tropical highlands of East and Central Africa and Madagascar, rice is produced up to 1900 MASL (Fig. 5.2). This zone includes fertile rolling uplands, high plateau, and mountainous terrain in the archipelago stretching from Ethiopia southward to Angola and Zimbabwe and has some of the best agricultural lands in Africa (HarvestChoice 2014).

The high elevation consists of both upland and aquatic ecologies. The primary constraints are altitudinal low temperatures and flooding during the cropping season (Zenna et al. 2010) (Table 5.2). National and international agricultural research centers give this zone special attention because of its potential for rice production, intensification and expansion, and its unique requirement for cold-tolerant varieties. Several cold-tolerant varieties with japonica genetic background have been introduced, tested and released through the AfricaRice breeding task force mechanism (Zenna 2015). Varieties with temperate japonica genetic background, which thrive well in cold-prone areas, are more adapted to this ecology than those with indica

Fig. 5.2 Rice production at Betafo, Madagascar; high elevation plateau, 1800 MASL, in Madgascar (Photo: Moussa Sie)

genetic background. Japonicas can be furthermore subdivided into tropical japonica and temperate japonica, and both are being cultivated in Africa.

5.4 Genetic Resource Utilization

The plethora of biotic and abiotic stresses that constrain rice production in Africa and climate change provide a great opportunity for developing varieties that perform well under dynamic stress conditions. The AfricaRice gene bank contains more than 20,000 rice accessions, including 2500 *O. glaberrima* (Sie et al. 2012) and offer a unique opportunity for collaborative breeding programs to generate new varieties in demand.

The earliest breeding programs in Africa focused on the introduction of varieties from Asia and many aquatic rice varieties were successfully released under the name “Sahel”. However, there were no introductions for the upland ecology. To strengthen the rice breeding programs of national agricultural research institutions in SSA, AfricaRice (formerly known as WARDA) established regional breeding initiatives through which WAB 56–50, WAB 56–104, and WAB 56–125 were developed for the upland ecology before the advent of the New Rice for Africa (NERICA) varieties. NERICA varieties inherited desirable qualities of *O. glaberrima* (e.g. drought tolerance, weed competitiveness, and diseases tolerance) and the high yielding potential of *O. sativa* (Jones et al. 1997; Dingkuhn et al. 1999). The most desirable quality attributes of NERICA varieties are early maturity, tolerance of specific biotic and abiotic stresses, and yields that are generally as good as for *O. sativa* varieties (Sie et al. 2012). There are currently 18 upland NERICA (NERICA 1–18) and 60 lowland NERICA (NERICA-L 1–60) varieties. NERICA 4 (rainfed upland) and NERICA-L 19 (rainfed lowland and irrigated ecologies) have been widely adopted by many countries in Africa. They were released through the participatory varietal selection system (PVS) (Sie et al. 2010) initially in Guinea in the 1990s and later in several countries across the continent. Nigeria has adopted NERICA 1 and NERICA 2 on about 200,000 ha. In Uganda, different NERICA varieties were cultivated on 35,000 ha in 2007 alone, and this enabled the country to halve its rice imports between 2002 and 2007. Similar successes have been reported in other countries, such as Burkina Faso, Ethiopia, Guinea, Mali, Sierra Leone, Liberia, and Togo (Tollens et al. 2013). The impact of NERICA adoption on poverty reduction in Benin and Uganda has been documented (Sie et al. 2012). Consequently, NERICA has become a brand name for good rice in Africa and is probably better known than AfricaRice, the organization that developed it (Sie et al. 2012).

PVS was an essential vehicle for sensitizing rice producers to adopt NERICA varieties—many rice lines were presented to farmers in village-based demonstration plots. Farmers were then asked to select their favorite lines at various stages of plant growth and to indicate the reasons for their choices. Over the following two seasons, farmers took increasing control of their chosen "varieties". Special attention was paid to feedback from women (Fig. 5.3), because most of Africa's rice farmers are women, and their preferences often turned out to be quite different from those of men. PVS data were also used to facilitate the varietal release process and seed production and the quick adoption of varieties. The PVS technique worked well throughout West and Central Africa as part of the NERICA project, providing the farmers with their preferred varieties and generating valuable feedback for rice breeders (Sie et al. 2012).

Although conventional breeding has been successfully used to develop new varieties, it is essential to complement this with molecular breeding to accelerate the development of varieties with tolerance of abiotic and biotic stresses, especially those that are controlled by several genes. In collaboration with AfricaRice and other international organizations, National Agricultural Research Systems (NARS) scientists are now using genomic tools in their breeding programs to introduce traits of interest into local popular varieties (Ndjiondjop et al. 2013). For example, AfricaRice and its partners have identified several useful genes that are now introduced into a number of popular varieties through marker-assisted breeding technique (AfricaRice 2012; Ndjiondjop et al. 2013) and these are being used in marker-assisted breeding to improve many varieties in West Africa.

In response to the reality of climate change, the new breeding direction at AfricaRice is set to develop rice varieties that are resilient to the changing environment in Africa (AfricaRice 2010; Dramé et al. 2013). Consequently, AfricaRice has set up the Africa-wide Rice Breeding Task Force (BTF), a systematic continent-wide breeding approach involving a variety of partners. The BTF is expected to accelerate the development, exchange, and release of rice varieties (Mohapatra 2011). For example, it was used to launch "ARICA" ("Advanced Rice for Africa") (Kumashiro 2016) (Fig. 5.4), a new

Fig. 5.3 Participatory varietal selection (PVS) activities in the rainfed upland ecology in Ivory, Madagascar (Photo: Moussa Sie)

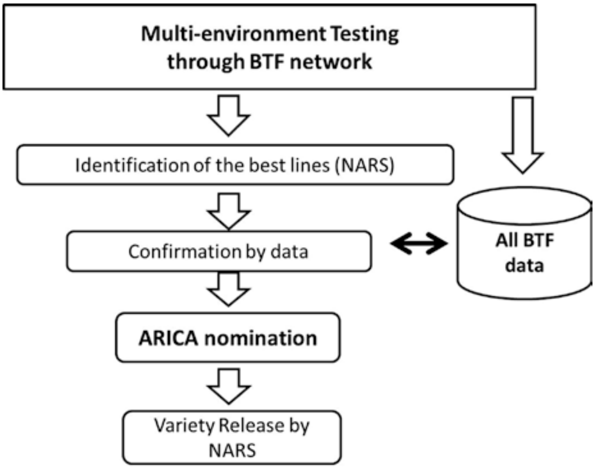

Fig. 5.4 Scheme for the development and release of Advance rice for Africa (ARICA) varieties through the Africa-wide breeding task force mechanism (Modified from (Kumashiro 2016) with permission)

generation of high-perfovrming rice varieties. ARICA varieties are the next generation of rice varieties for Africa, following the success of the NERICA varieties developed in the 1990s and the first decade of this century. Some of the 18 ARICA varieties nominated across ecologies through the BTF mechanism have already been released in Burkina Faso, Guinea Conakry, Mali, and Uganda (Kumashiro et al. 2013).

On the other hand hybrid rice production is gaining momentum in Africa. Starting from 2000, several African countries, such as Côte d'Ivoire, Liberia, Madagascar, Mozambique, Nigeria, Tanzania, and Uganda, have evaluated rice hybrids imported from China. Only Egypt has succeeded in developing a hybrid-rice breeding program and produces Egyptian hybrids on a commercial scale. Yields of 12–14 ton/ha have been reported for these hybrids (El Namaky and Demont 2013). Considering the potential of the hybrid technology, AfricaRice initiated a hybrid-rice program, based at its Sahel Station in Senegal, in 2010, to enhance irrigated rice production (AfricaRice 2010). The hybrid program is now an integral part of the BTF program. Thus 36 multienvironment trials were conducted for the first generation of hybrid lines in Nigeria, Mali, Senegal, The Gambia, and Mauritania through which hybrids with about 20 % yield advantage over the inbred lines were identified. Several of the hybrids emanating from the program are being tested in different countries. Such encouraging results from the breeding program coupled with a sustainable seed production mechanism will boost African rice production capacity (El Namaky and Demont 2013). Hybrid rice technology is expected to contribute to food security in Africa through: (i) exploitation of hybrid vigor to enhance productivity and (ii) involvement of the private sector in seed production research and development (El Namaky and Demont 2013; Kanfany et al. 2014).

5.5 Challenges and Opportunities in African Rice Production

There are large differences (3.2–5.9 ton/ha) between potential and actual yields obtained by farmers ("yield gaps") across all rice growing environments (Table 5.2) (Saito et al. 2013). There is, therefore, considerable scope for increasing yields (Becker et al. 2003). These yield gaps can be closed by introducing improved varieties and good agricultural practices (GAP). GAP is an integrated set of recommended crop, soil, water, and weed management practices (Nhamo et al. 2014). GAP for the lowland ecology may include animal or motorized traction for fine soil tillage, proper bund making, and leveling, use of certified seeds of improved varieties, sowing or transplanting in lines, application of judicious doses of composite fertilizers, and optimally timed weed control using appropriate herbicide dosages followed by weeding with mechanical weeders Becker et al. 2003; Rodenburg and Johnson 2009; Wopereis and Defoer 2007; Mghase et al. 2013; Senthilkumar et al. 2014. Integrated rice management (IRM) options developed by AfricaRice (Lancon 2002) include mechanization, soil-fertility management, and weed management and have increased yields by about 2 ton/ha and benefited farmers in Burkina Faso, Mauritania, and Senegal (Haefele et al. 2000, 2001; Segada et al. 2004, 2005). However, for timely and optimal field management operations, small scale machineries are indispensable.

Lack of appropriate tools for land preparation, harvesting, and postharvest operations is another major bottleneck that makes rice cultivation laborious and time consuming in Africa. For example, lack of appropriate machinery can delay rice harvesting and reduce grain quality (Rickman et al. 2013). The adoption of locally manufactured small-scale machinery is an essential support for rice production in Africa. Consequently, through its Mechanization Task Force, AfricaRice is assisting its NARS partners to identify small-scale machinery and adapting them to local conditions. Private manufacturers who are trained at AfricaRice are now producing and selling mechanical weeders, threshers, and harvesters in different countries (AfricaRice 2012). Availability of such tools can help rice producers to improve the quality of their product and avoid massive losses during the production process.

Crop production generates income for 70 % of farm households in SSA but postharvest losses significantly reduce farmers' real incomes—up to 35 % of the produce is lost during pre- and postharvest processes in the field (CGIAR 2013). Postharvest losses in SSA may be quantitative (15 % and 25 %) or qualitative (estimated by the price difference in imported and locally produced rice) (15–50 %). In Nigeria alone, an estimated 25 % of the total local production is lost due to inefficient postharvest handling and processing (Oguntade et al. 2014).

A reduction in the pre- and postharvest losses is necessary to ensure good quality produce and make rice cultivation a profitable business. Grain quality depends not only on the variety, but also on the whole crop production environment and postproduction management (Futakuchi et al. 2013). In general, locally produced rice in Africa is of lower quality than imported rice, is unable to compete favorably with imported rice, and thus has a limited market share (Manful 2012). Currently, grain quality analysis is carried out on all accessions and breeding lines nominated for multienvironment trials at AfricaRice. The evaluation includes cooking and tasting qualities and aroma. Only entries that satisfy the basic requirements are then distributed for evaluation through the BTF mechanism (Futakuchi et al. 2013). The concern for grain quality could be of major importance to the market; however, quality seed availability could have an immense value for producers to deliver the quality product.

Most African countries have weak seed systems that lack the necessary staff, equipment, and funding. This hinders the availability of sufficient quality seed of

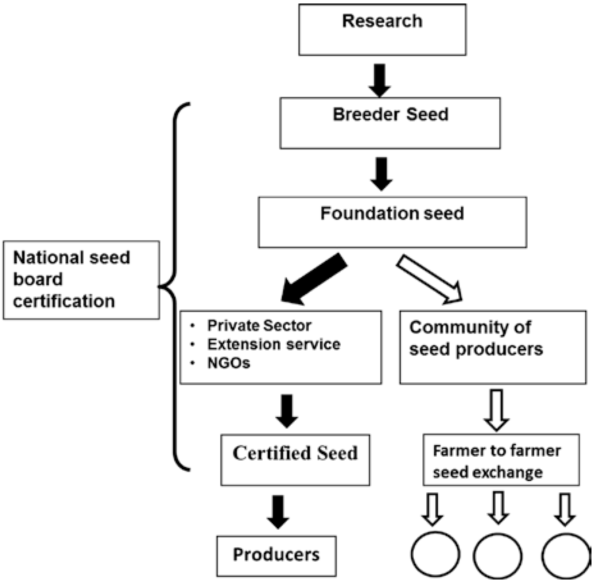

Fig. 5.5 Seed production scheme in Africa—conventional seed production is indicated by solid arrows, while community seed production system (CBSS) is shown with dotted arrows (Adapted from (Sie et al. 2010) with permission)

newly released varieties (AfricaRice 2011). To alleviate this problem, AfricaRice developed the community-based seed systems (CBSS) in the late 1990s, where farmers are trained in best practices for producing "seed of acceptable quality" on their farms for themselves and their neighbors (Fig. 5.5) (Sie et al. 2010). CBSS shortens the time required for seed of improved varieties to reach farmers (Bèye et al. 2013; Sie et al. 2010). There are also regional initiatives, such as by the Economic Community of West African States (ECOWAS) and the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) for making the seeds of improved varieties available to farmers (Norman and Kebe 2006; Waithaka et al. 2012; Kuhlmann 2015). A sustainable and efficient seed production and delivery system in Africa can be developed in partnership between the private and public sectors. However, such strategic alliance can only prosper by the presence of dynamic national policy for agriculture.

AfricaRice has assisted many countries to prepare their national rice development strategies (NRDS) under the Coalition for African Rice Development (CARD) initiative (JICA 2009). There has been a gradual shift in policy in favor of developing whole rice value chain. The "rice sector development hubs" is an innovative institutional approach to the rice value chain mechanism. Rice hubs are geographical areas where research products, services, and local innovations are integrated across the rice value chain to achieve development outcomes and impact. Hubs are testing grounds for new rice technologies and follow a "reverse-research approach", i.e., starting from the market. In the hubs, research innovations, outputs, and products are tested, adapted, and integrated into "baskets of good agricultural practices". Hubs are built around large groups of farmers and involve other value chain actors and extension agencies that work together to evaluate technological and institutional innovations, facilitate diffusion of knowledge and establish linkages along the rice value chain.

5.6 Conclusions

Rice cultivation in Africa has a long history and has shaped the diet of millions of people. In addition to being a staple food in many rice producing countries, it is also a cash crop for nearly 70 % of the population that earns its income from agriculture. Consequently, rice is considered as the "white gold" of Africa, which is expected to contribute to poverty alleviation and food security on the continent. Based on the positive political will and interventions that produced outstanding achievements since the 2008 rice crisis, it will not be long before Africa produces enough rice to meet its requirements and for export. However, to realize this potential and capitalize on the current demand-driven production momentum, there is a need to inject adequate technological and financial investments into the rice sector. Such investment in innovation platforms would galvanize the whole value chain and the resulting scaling-out of relevant technologies would ensure sustainable rice production (Tollens et al. 2013; Wopereis et al. 2013).

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