Food Fortification Initiative
Enhancing Grains for Healthier Lives

gain
Global Alliance for Improved Nutrition

Feasibility and Potential Coverage of Fortified Rice in the Africa Rice Supply Chain

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and the Global Alliance for Improved Nutrition (GAIN)

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Cover photo: Women harvesters eating the rice dish *yassa* from a communal bowl: http://www.foodarts.com/news/features/25984/african-rice-cycle

Updated October 2017 with FAO 2013 statistics. According to these statistics, Sao Tome and Principe is another African country that would have qualified for inclusion in this supply chain if using the updated rice availability estimates. However, as Sao Tome and Principe's total rice volumes (7,000 MT annually) and population (est. 200,0000) are relatively small and would not greatly impact the report's conclusions, Sao Tome and Principe's data was not added to this updated report and a profile was not developed.

Abbreviations

FAO: The United Nations Food and Agriculture Organization
FFI: Food Fortification Initiative
G/c/d: Grams per capita per day
GAIN: Global Alliance for Improved Nutrition
Ha: Hectare
ISO: International Standard Organization
MT: Metric ton
MMT: Million metric tons
USAID: United States Agency for International Development
USDA: United States Department of Agriculture
WHO: World Health Organization
WFP: World Food Programme

Terms[1]

Availability: In this report, consumption data specifically refers to information gathered from nutritional assessment tools (i.e. 24-hour recalls, food frequency surveys, etc.). In most countries these surveys are not available and instead, food availability is referenced. Availability (or food supply) is calculated from summing food sources (e.g. production, imports) and subtracting nondomestic or nonfood uses (e.g. exports, feed, seed, waste).

Blending: Mixing of milled, non-fortified rice with fortified kernels in ratios between 0.5% and 2% to produce fortified rice. Blending can be done at a rice miller, warehouse, or other location where rice is centrally processed. Small-scale blending technology is also available.

Bonded warehouse: A warehouse authorized by customs authorities for storage of goods on which payment of duties is deferred until the goods are removed.

Break-bulk: Bagged grain shipped as non-containerized cargo stowed directly into a ship's hold.

Brown rice: Rice with only the hull removed. Bran layers and germ remain, giving the rice a brownish color. Brown rice can be a source of vitamins B1, B6, E and niacin, but nutrient content ranges widely based on the rice variety.

Bulk: Loose grain shipped as non-bagged, non-containerized cargo stowed directly into a ship's hold.

Coating: Technology to make fortified kernels. Rice kernels are coated with a fortificant mix plus ingredients such as waxes and gums. Micronutrients are sprayed onto the rice grain's surface. Coated rice kernels are blended with non-fortified rice in a ratio between 0.5% and 2%.

Container: Steel or aluminum frame forming a box in which cargo can be stowed meeting International Standard Organization (ISO)-specified measurements. Containers are fitted with special castings on the corners for securing to lift equipment, vessels, chassis, rail cars, or stack on other containers. Containers come in many forms and types, including: ventilated, insulated, refrigerated, flat rack, vehicle rack, open top, bulk liquid, dry bulk, or other special configurations. Containers may be 10-53 feet in length, 8 feet or 8.5 feet in width, and 8.5 feet or 9.5 feet in height. A standard 20-foot container is holds 20-24 metric tons of grain.

Extrusion: Technology to make fortified kernels. Rice-shaped reconstituted kernels are produced by passing rice flour dough, containing a fortificant mix, through an extruder.

[1] Definitions adapted from 1.) Seine Maritime's Glossary of Port and Shipping Terms, accessed at: http://www.seinemaritime.net/suports/uploads/files/Glossary%20of%20Port%20and%20Shipping%20Terms.pdf; 2.) Sight & Life's Scaling Up Rice Fortification in Asia supplement, 2015.

The extruded kernels resembling rice grains are blended into non-fortified rice in a ratio between 0.5% and 2%, similar to the coating technology. Extrusion uses broken rice kernels as an input and may be carried out under hot, warm, or cold temperatures. The temperature influences the appearance and performance of the final fortified kernel.

Fortified kernel: Fortified rice-shaped kernels containing the fortificant mix (extrusion) or whole rice kernels coated with a fortificant mix (coating). Fortified kernels are blended with non-fortified rice to produce fortified rice, usually at a 0.5-2% blending ratio).

Fortified rice: Rice with vitamins and minerals added with any technology.

Free trade zone: An area, often within a port, designated by the government of a country for duty-free entry of any non-prohibited goods. Merchandise may be stored, displayed, or used for manufacturing within the zone and re-exported without duties being applied. Also referred to as free port.

Lighter: An open or covered barge towed or pushed by a tugboat or a pusher tug and used primarily in harbors and on inland waterways to carry cargo to or from the port.

Metric ton: All references to tonnage in this report are specific to metric tons. One metric ton is equivalent to 1,000 kilograms.

Milled rice: Rice from which the hull, bran layer, and germ have been removed. This is also referred to as polished rice. See also brown rice and parboiled rice.

Paddy rice: Unmilled rice, with hull, bran layer, and germ attached.

Parboiled rice: Rice that has been partially boiled in the husk. The three basic steps of parboiling are soaking, steaming and drying. Parboiling makes rice easier to process by hand and changes its texture. Parboiling drives water-soluble nutrients from the bran to endosperm, hence parboiled white rice contains roughly half the water-soluble vitamins from brown rice, and is slightly more nutritious than unfortified milled rice.

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Executive Overview

Outside of Asia, the largest per capita rice consumption is in Africa. Of the 37 MMT of rice globally traded in 2015/16, 11.7 MMT was exported to Africa[2]. Nineteen countries in Africa have more than 75 grams per capita per day of rice available on average for human consumption[3]. These countries represent the first strata of opportunity – populations where rice consumption is likely to reach large swathes of the population and consumed in quantities adequate for a public health benefit through fortification.

However, national-level availability and consumption alone do not tell the entire picture. To ensure feasibility and describe potential for impact, there is a need to better understand consumption patterns among specific populations (e.g. women of reproductive age, rural populations), the overlap with other fortified/fortifiable food vehicles (e.g. maize and wheat flour) as well as the rice import and domestic rice milling industries. This assessment focuses on this latter supply side issue. The Food Fortification Initiative (FFI) and the Global Alliance for Improved Nutrition (GAIN) used primary and secondary data to identify rice fortification opportunities (both domestic and import markets) in Africa and developed 19 country profiles.

This work identified 12 countries as opportunities for rice fortification because imports are a dominant source of rice for urban areas or the entire population. Domestic milling capacity to implement rice fortification is not yet feasible in any of the countries studied, so imported rice remains the main opportunity for fortification in Africa. In seven of the 12, the urban population is the main potential beneficiary, either because the rural population primarily consumes traditional alternative sources of carbohydrates, or farmers grow rice for self-subsistence.

The collective population considered potential beneficiaries of rice fortification in these 12 countries is 130 million, or 33% of the total population in the 19 countries. Four countries were not considered an opportunity for rice fortification given dominant dependence on local small mills, and another three countries were considered unknowns because further data is required.

In 2014/2015, an estimated 5.7 MMT of rice was imported into the 12 opportunity countries. Fortifying all this rice via extrusion technology could require nine extruded kernel production lines (depending on their capacity); this relatively low volume indicates that individual country efforts will be inadequate to generate private sector investment in rice fortification. While rice fortification in Africa represents an opportunity to reach a large population across several nations, rice fortification at scale will require a regional effort for mandatory rice fortification and/or a significant leverage of publically-funded food programs (e.g. food distribution, school meals). Efforts on a single country-by-country basis will not lead to sufficient fortified rice demand to justify private sector investment in fortified kernel production.

Significant barriers to fortification, including protective national rice self-sufficiency policies and unofficial trade across porous land borders, counterbalance these opportunities. Moving forward with rice fortification will depend on successful navigation of politically sensitive rice policies, opportunities to use food distribution programs, and effective regulatory monitoring.

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[2] USDA. Foreign Agricultural Service, October 2016. Grain: World Markets and Trade. http://apps.fas.usda.gov/psdonline/circulars/grain.pdf

[3] FAO 2013 Food Balance Sheets. http://faostat3.fao.org/

Introduction

Fortification as a public health intervention to improve micronutrient status has been practiced since the early 1900s when Switzerland added iodine to salt to reduce iodine deficiency disorder, severe symptoms of which are goiter and cretinism[4]. In the 1940s, cereal grain fortification began with wheat flour, to which iron, niacin, thiamin, and riboflavin was added to prevent conditions such as pellagra and beri beri[5]. Fortification of other staple food vehicles, such as oil, sugar, and other condiments is also practiced in multiple countries[6].

Because rice is predominantly consumed as a kernel, not as flour (such as wheat or maize), fortification of rice to improve micronutrient status has been more challenging to implement on a global scale. As early as the 1940s, Philippine researchers found that rice fortified with thiamin dramatically reduced the prevalence of beriberi, which was the second cause of death at that time after tuberculosis[7]. To date, FFI estimates that less than 1% of the industrially milled rice globally is fortified[8]. In comparison, FFI estimates approximately 28% of industrially milled wheat flour and 58% of industrially milled maize flour is fortified with at least iron and folic acid[8]. Globally, 85 countries have mandatory legislation to fortify wheat flour with at least iron or folic acid, whereas only six countries have mandated rice fortification[9]. The vast majority of the population that depends on rice as its staple cereal grain has yet to benefit from improved micronutrient status from fortification.

Rice fortification technology

The two recommended technologies for rice fortification are coating and extrusion[10]. Nutrients added via these processes are resistant to being washed off as rice is prepared for cooking[11]. In both technologies, a fortified kernel must first be produced (either by a miller or an external producer) then blended with milled rice (Figure 1).

[4] Staub K, et al. "From growth in height to growth in breadth': The changing body shape of Swiss conscripts since the late 19th century and possible endocrine explanations. General and Comparative Endocrinology 188 (2013) 9–15

[5] Bishai D, et al. The History of Food Fortification in the United States: Its Relevance for Current Fortification Efforts in Developing Countries. Economic Development and Cultural Change, Vol. 51, No. 1 (October 2002), pp. 37-53

[6] World Health Organization. Food Fortification. Global database on the Implementation of Nutrition Action (GINA). Accessed at https://extranet.who.int/nutrition/gina

[7] Salcedo J Jr., et al. Artificial Enrichment Of White Rice As A Solution To Endemic Beriberi. J Nutr. 1949 Aug;38(4):443-51

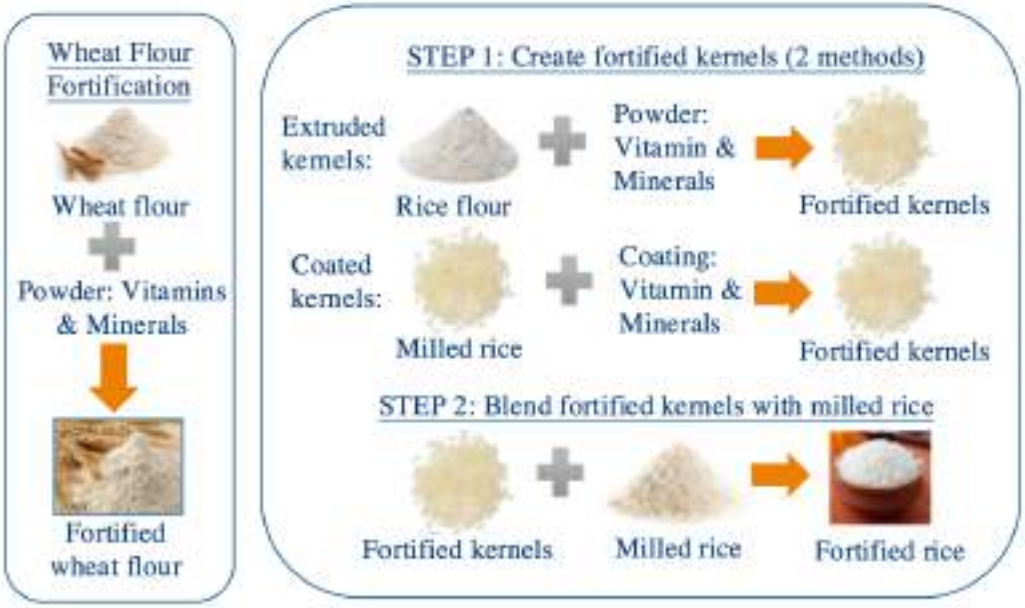
[8] FFI Year in Review, 2015. Accessed at: http://www.ffinetwork.org/about/stay_informed/releases/2015Review.html

[9] FFI Network. Global Progress. 2016. Accessed at: http://www.ffinetwork.org/global_progress/index.php

[10] Montgomery, SJ. Technology for Rice Fortification. In: Scaling Up Rice Fortification in Asia, Sight & Life 2015, pp 57-62

[11] Wieringa FT, et al. Stability and retention of micronutrients in fortified rice prepared using different cooking methods. Ann N Y Acad Sci. 2014 Sep;1324:40-7

Figure 1: Fortification steps for wheat flour and rice



The two recommended technologies to fortify rice are[12]:

1. Coating: milled rice is coated with a concentrated liquid vitamin-mineral premix, suspended in a wax or gum. The fortified kernels are then dried. Fortified kernels are blended with non-fortified milled rice (at a ratio ranging from 0.5%-2%) to create fortified rice. Coating technology must be rinse-resistant to prevent nutrients from being washed off the kernel. However, nutrients may seep into the water during cooking, making coating ineffective in cultures where excess water is poured off during the cooking process.

2. Extrusion: rice flour is mixed with a concentrated vitamin-mineral premix and water to create dough, shaped into rice-shaped kernels by an extrusion machine and then dried. As with coating, the fortified kernels are then blended with milled rice (at a ratio ranging from 0.5%-2%) to create fortified rice. Since the vitamin-mineral premix is in the entire kernel, extruded fortified kernels are rinse resistant.

In both technologies, the aim is to create fortified rice that looks, smells, and tastes similar to non-fortified rice. Although fortified rice with colored kernels has been marketed as a specialty product, mass fortification efforts indicate colored or discoloration in kernels is not preferred[13]. Blending at lower kernel-rice ratios (e.g. 1:200 versus 1:50) would achieve the lowest cost per metric ton (MT) to fortify; however the feasibility of low blending ratios depends on the nutrient specifications for rice fortification. Using higher amounts of certain nutrients (particularly iron) could affect the appearance of fortified rice blended at 1:200[14,15]. Color concerns are an issue in

[12] For the purposes of this report, parboiling is not considered a fortification method. Parboiling is a heat treatment applied to paddy rice, which causes some of the intrinsic nutrients in bran to migrate into the endosperm. After parboiling, rice is husked. Parboiling methods to externally add nutrients also exists but are still in proof of concept phase.

[13] Alavi S, et al. Eds. Rice Fortification in Developing Countries: A Critical Review of the Technical and Economic Feasibility. A2Z Project. April 2008.

[14] Blending at 1:200 may also not be technically possible if target nutrient levels are very high. For example, 120 mg/kg of iron (as ferric pyrophosphate) is considered to produce kernels with a slight grey color.

populations that prefer highly polished, homogenous rice. In these populations a higher kernel-rice blending ratio can increase nutrient density of rice fortification but will add to per MT costs. Estimations for kernel production capacity in this report assume 1:200 blending ratios.

Rice fortification at scale

Given the extra step required to create coated and extruded fortified kernels, rice fortification requires infrastructure for creating these kernels – not required in the fortification of wheat and maize flour. Consequently, the cost of fortifying rice is on average seven times the cost of fortifying flours (Table 1).

Table 1: Fortification inputs and costs

Wheat/maize flour	*Rice*
1. Premix dosifier ($8,000-10,000 US; capital cost) 2. Premix ($3 US/MT; ongoing cost) (Precise cost depends on nutrient composition)	1. Fortified kernel production line (~$1-2 million US; capital cost[16]) 2. Fortified kernel dosifier (est. <$30,000 US; capital cost) 3. Fortified kernels ($20 US/MT[17]; ongoing cost) (Includes: premix and production costs related to producing the kernel)

Thus, the current conundrum for rice fortification is that without demand for fortified rice, fortified kernels remain expensive. But with expensive fortified kernels, few rice producers are willing to compete with less expensive, non-fortified rice. Fortified kernel manufacturers today run at low volumes to supply kernels for small volumes of fortified rice (e.g. pilot projects, food distribution programs)[9]. But at low volume production, kernel manufacturers also are unable to take advantage of economies of scale that would allow them to price kernels more competitively – thus the high per MT cost.

At what volumes could fortified kernel manufacturers operate at optimal economies of scale? In other words, what quantities of fortified rice could be considered adequate demand for private industry to invest in fortified kernel production? Table 2 compares the volumes of fortified rice necessary at varying fortified kernel blending ratios.

[15] de Pee, S. Proposing nutrients and nutrient levels for rice fortification. Ann N Y Acad Sci. 2014 Sep;1324:55-66

[16] Estimated investment for the installation of a 250 kg/hr or 500 kg/hr kernel production line, quote from Buhler Food (Wuxi). Personal Communication, 2014.

[17] Calculated based off of estimated fortified kernel quotes from Buhler Food (Wuxi). Personal Communication, 2016

Table 2: Potential fortified kernel production and fortified rice volumes[1]

Coated kernel plant		**Extruded kernel line**	
Minimum production requirement: 50,000 MT/year of fortified kernels[2]		3 lines available: 0.25MT/hr 0.5 MT/hr 1 MT/hr	
Blending ratio	Fortified rice (MT)	Blending ratio	Fortified rice (MT)
1:49	2.5 MMT/year	1:49	
		0.25 MT/hr	90,000 MT
		0.50 MT/hr	180,000 MT
		1 MT/hr	360,000 MT
1:99	5 MMT/year	1:99	
		0.25 MT/hr	180,000 MT
		0.50 MT/hr	360,000 MT
		1 MT/hr	720,000 MT
1:199	10 MMT/year	1:199	
		0.25 MT/hr	360,000 MT
		0.50 MT/hr	720,000 MT
		1 MT/hr	1.44 MMT

MT, metric tons; MMT, million metric tons
[1] Assuming that a plant running at optimal efficiency is operating 24 hrs. x 300 days a year.
[2] Personal communication from Wright Group, 2014

Putting these fortified rice volumes in perspective, the 19 African rice-consuming countries in this report imported 7.2 million metric tons (MMT) of rice in 2014/2015[18]. The entire continent imported 11.7 MMT overall[2]. At these volumes, one coated kernel plant could produce enough fortified kernels to supply almost the entire African continent with fortified rice (blending at 1:200 ratio). Given this massive volume requirement and the potential logistical barriers with sourcing fortified kernels from a single production facility, extruded kernel lines (which may be installed in existing extrusion plants or rice mills) allow for greater sourcing flexibility. A 1 metric ton (MT/hr) extruded kernel line could produce enough fortified kernels (7,200 MT/year) to fortify 1.44 MMT of rice (blending at 1:200 ratio).

Africa: The Second Largest Rice Market After Asia

The Asian continent is the largest producer and consumer of rice: 87% of the world's rice is grown in Asia, and 90% of the rice stays in Asia to feed its own inhabitants[19]. But rice fortification is difficult to implement in many parts of Asia because the rice milling industry in large part remains small-scale. These operators typically mill for self-consumption or local trade. Fortification in a fragmented milling industry, with thousands of mills producing low volumes (often using inefficient technology) is not cost-efficient to implement and virtually impossible for governments to enforce. In the key Asian rice export countries, industrially milled rice is destined for export and the locally milled riced comes from small producers.

[18] UN Comtrade 2014; for countries where 2014 data was not available or in conflict with FAO and USDA data, 2015 exporting country data was used. Accessed at http://comtrade.un.org/
[19] Abdullah AB, et al. Estimate of Rice Consumption in Asian Countries and the World Towards 2050. Kyushu University, Graduate School of Agricultural Research and Institute of Agricultural and Resource Economics. Accessed at: http://worldfood.apionet.or.jp/alias.pdf

Consequently Asia has limited opportunities for rice fortification except for a few countries where the milling industry is already modernized: Brunei, China, Hong Kong, Macau, Korea, Japan, and Singapore[20]. For the reasons mentioned above, rice fortification is far more challenging in the Asian countries where rice fortification would have greater public health impact (e.g. Viet Nam, Indonesia, Laos, Cambodia, Myanmar, Philippines)[21].

The rice consuming areas of African present the potential to scale up rice fortification in the short-term, while the rice milling industry in Asia continues to modernize. Outside of Asia, the greatest per capita consumption of rice occurs in West Africa; its 6.4 MMT of rice is imported annually mainly from Thailand, India, Pakistan, and Viet Nam[18]. Although the domestic rice milling industry in the Asian countries may not have capacity to fortify rice, a consolidated export-driven rice industry in these countries involves some of the largest rice mills in the world – with potential capacity to fortify to meet other countries' mandatory rice fortification laws.

Thus the objective of this Africa rice supply chain analysis was to describe the situation for rice imports into the African continent: which countries in Africa consume rice in adequate amounts for a public health impact? What are the rice import origins and varieties for each of these African countries? Who are the main suppliers of rice, and how is the rice handled upon entry? And finally, what is the potential coverage of rice fortification in the opportunity countries, and what volume of fortified rice does this demand meet?

Methods and Data Sources

Using the 2011 FAO Food Balance Sheet database, 18 countries in the African continent were identified as having at least 75 g/c/d of rice available in the food supply (Table 3) From there, 11 countries were selected for field-visit prioritization[22]. Key Consulting conducted field visits during September-December 2015 for all countries except Madagascar and Comoros, which were visited during April 2016. Secondary data sources included UN Comtrade for bilateral rice trade data, both FAO and USDA for rice import (as aggregated by IndexMundi), production, and consumption in each country, USDA Foreign Agriculture Service Grain and Feed Annuals, the USAID 2009 West Africa Value Chain Analysis, and CIA World Factbook for population and urbanization estimates and trends. FFI conducted a desk reviews for other relevant documents related to country or region-specific consumption surveys, rice policies, rice pricing, consumer preferences, regulatory monitoring, and rice-related media.

A nutrition survey scan was conducted to understand what micronutrient deficiency data existed for each country. As micronutrient data was not consistently available, WHO's 2015 national estimates for anemia prevalence in young children and non-pregnant women of reproductive age[23] were used as a proxy to depict the nutritional gap in the countries of interest (Table 4).

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[20] FFI, WFP, WHO, GAIN. Strategic Paper: Fortification of rice and wheat flour with vitamins and minerals in the Western Pacific region. WHO WPRO Consultation on the Regional Action Plan to Reduce the Double Burden of Malnutrition in the Western Pacific Region, October 2013.

[21] The Philippines already requires mandatory fortification of rice. However, it is not fully implemented due to the milling industry/enforcement reasons already stated.

[22] FAO does not have any data available for the Union of Comoros so it was not initially listed in the countries with rice availability >75 g/c/d. However it was opportunistically included in the analysis due to a visit by Key Consulting, which indicated that rice availability in the small island chain exceeds 75 g/c/d.

Table 3: African countries with over 75 g/c/d of rice available (FAO 2013)

West Africa	Outside of West Africa
Benin	*Comoros*[22]
Cabo Verde	*Djibouti*
Côte d'Ivoire	*Egypt*
Gambia	*Gabon*
Ghana	*Madagascar*
Guinea	*Mauritius*
Guinea-Bissau	
Liberia	
Mali	
Mauritania	
Nigeria	
Senegal	
Sao Tome and Principe	

Table 4: Estimated anemia prevalence in women and children[23],[24]

Countries	Anemia in children 6-59 mos, %	Anemia in non-pregnant women 15-49 yrs, %
Benin	65	48
Cape Verde	60	38
Comoros	51	30
Côte d'Ivoire	75	48
Djibouti	43	27
Egypt	45	35
Gabon	60	50
Gambia	65	44
Ghana	76	56
Guinea	76	47
Guinea-Bissau	71	44
Liberia	72	49
Madagascar	50	32
Mali	80	56
Mauritania	71	38
Mauritius	44	23
Nigeria	71	47
Senegal	79	57
Sierra Leone	74	45

Highlighted numbers indicate where estimates exceed WHO's "severe" classification of public health significance (≥40%) for anemia prevalence.

[23] WHO. The global prevalence of anaemia in 2011. Geneva: World Health Organization; 2015.

[24] WHO. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. Vitamin and Mineral Nutrition Information System. Geneva, World Health Organization, 2011 (WHO/NMH/NHD/MNM/11.1) (http://www.who.int/vmnis/indicators/haemoglobin.

Supply chain companies

Rice importers

Field visits identified rice importers in 13 out of the 19 countries. From this limited information, compared to rice trading and exporting, the rice importing industry is relatively less consolidated and dominated by international companies. Only eight of the countries with a rice importing company also have global or regional subsidiaries. In only one of those 13 countries (Comoros) was a government agency the primary source for imported rice.

Five companies were operating in more than one country, both as direct importers and supplying traders (Table 5). This list should be considered partial, as not 100% of importers and their suppliers were identified.

Table 5: Multinational rice importing companies

Company	Operating countries
Stallion Group	Benin (Sonam Group) Ghana (Stallion) Nigeria (Stallion)
Olam	Ghana Nigeria Liberia (as a supplier, not direct importer) Senegal (operates under subsidiary *Societe Senegalaise de Marchandises Alimentaires*)
Phoenix Trading/Commodities	Côte d' Ivoire (as a supplier, not direct importer) Sierra Leone
Louis Dreyfus Company	Senegal Côte d' Ivoire (as a supplier, not direct importer) Gambia (as a supplier, not direct importer) Guinea (as a supplier, not direct importer) Liberia (as a supplier, not direct importer) Sierra Leone (as a supplier, not direct importer)
Cereal Investments Company (*Compagnie d' Investissements Céréaliers*)	Cabo Verde Côte d' Ivoire Ghana Guinea Bissau Senegal

Rice traders

Global rice trading companies active in Africa are Archer Daniels Midland (ADM), Louis Dreyfus (LD) Company B.V., Ameropa, Cereal Investments Company, Swiss-Trade, Ascot Commodities, Phoenix Trading/Commodities, Churchgate, and Olam. LD Company is the world's leading rice trader with about 2 MMT in annual volumes, an estimated 8% of total global trade[25]. It claims to be the number one distributor in West Africa, as well as the number one sourcing company in Latin America and Asia. LD Company sources rice from 11 countries.

[25] Louis Dreyfus Company, 2015 Annual Review. Accessed at: https://www.ldcom.com/files/4214/5854/5171/LDC-AR-2015.pdf

Singapore-based Olam is the second largest global trader of rice[26] and has offices in Gabon, Côte d' Ivoire, Ghana, Nigeria, and Senegal. Olam's rice activities in the region are focused in Ghana, Nigeria, and Senegal[27] in particular. It is one of the largest rice importers in Ghana, working with over 320 distributors in the country[28]. It also owns a rice mill in Nigeria producing 36,000 MT of rice annually for its local brands[29]. Olam Togo also imports rice[30], which could be a source for re-exported rice to Nigeria. In 2015, Olam exited from rice distribution in Côte d' Ivoire[31].

Stallion Group is a large regional player, especially in Nigeria. It reports sourcing from Thailand, India, Viet Nam, Brazil and USA for its rice[32].

Rice exporters

Thailand exported 9.8 MMT of rice in 2015 (Table 6). The top five rice exporters accounted for almost half of that quantity (4.7 MMT). Asia Golden Rice and Capital Rice Group closely vie for first and second place (1.6 and 1.4 MMT respectively); the remaining exporters in the top 5 trail after with less than 1 MMT each.

Table 6: Top 5 rice exporters in Thailand, 2015[33]

Name	*MMT*
Asia Golden Rice	1,638,253
Capital Rice Group	1,424,030
Thanasan Group	728,365
C.P. Intertrade	576,798
Thai Hua Group	401,094
Other	5,027,223
Total	**9,795,763**

MMT, million metric ton

Other reportedly major rice exporters are: Nishita Shah, President Rice, Patum Rice Mill & Granary Public Co. Limited, Kamolkij (5%), CP Intertrade, Olam Thailand, President Agri Trading, and Siam Indiga[34]. Capital Rice Group is known to supply Stallion Group in Nigeria[35].

Importers report that in Thailand three major re-processors control about 80% of all rice exports to West Africa. Each importer buys milled rice from dozens of mills and stores it bulk in silos and warehouses, often using grain chilling to prevent pest infestation. These re-processors sort

[26] Olam Group. Rice. http://olamgroup.com/products-services/food-staples-packaged-foods/rice/

[27] Olam Group. Senegal. http://olamgroup.com/locations/west-central-africa/senegal/

[28] Olam Group. Ghana. Available at: http://olamgroup.com/locations/west-central-africa/ghana-main-page/

[29] Olam Group. Nigeria. Available at: http://olamgroup.com/locations/west-central-africa/nigeria/

[30] Olam Group. Togo. Available at: http://olamgroup.com/locations/west-central-africa/togo/

[31] Olam Group. 2015 Annual Report. http://olamgroup.com/wpcontent/uploads/2016/04/Olam_Annual_Report_2015.pdf

[32] Stallion Group. Rice. http://www.stalliongroup.com/rice.html

[33] Asia Golden Rice. Thailand Top 5 Rice Exporters, 2015. http://www.asiagoldenrice.com/Thailand-Top-5-Rice-Exporters.php

[34] Burkitt, L. Where Are the Rice Fortunes? Forbes.com. July 11, 2008. http://www.forbes.com/global/2008/0721/063a.html

[35] Thai Rice Exporters. Africa beckons for rice firms; besides imports, some countries seek farmers. April 17, 2009. http://www.thairiceexporters.or.th/Int%20news/News_2009/int_news_170409-1.html

and clean the rice to produce just the right quality in terms of broken percentages.
Olam Thailand operates a processing and export facility in Bangkok and counts itself as one of the top 10 exporters in the country, aggregating rice from more than 100 mills[36]. Olam Viet Nam also describes itself as a large purchaser of rice. It is not clear if Olam India procures rice; Olam South America appears to be focused on coffee exports.

Although Viet Nam is often the second or third-ranked rice exporter globally, much of Viet Nam's exports are targeted towards government-to-government sales in Asia, such as China, Indonesia, Malaysia, and the Philippines[37]. Compared to Thailand and India, Viet Nam's penetration into the African rice market is limited, approximately 8% according to UN Comtrade's 2014/2015 records[18]. Viet Nam's rice exports are the monopoly of a two state export trading companies, Vinafood 1 (based in Hanoi) and Vinafood 2 (based in Ho Chi Minh City). Although these two para-statal companies have the largest share of rice exports in the country, their market share has fallen since the industry was liberalized in the 1990s. Industry data shows that for June 2014, 95 companies exported rice, of which Vinafood 1 and Vinafood 2 had only 14% and 18% share respectively[38].

Very little is known about the rice exporting industry structure in Pakistan and India, the two other major country origins for rice imported to Africa

The Rice Exporters Association of Pakistan counts more than 1500 members in its roster, and reports exporting 3.3 MMT of rice in 2013/2014, 78% of that non-Basmati rice[39]. The Middle East and Africa are the main importers of Pakistani rice.

The All India Rice Exporters association counts 135 members on its roster, but of those only 15 are described as merchant exporters or traders. The bulk are manufacturer exporters and rice millers[40].

Collateral management and inspection companies

Exporting and importing rice, particularly the long distances from Asia to Africa, is fraught with risk – risk of loss through spoilage, piracy, pilferage, or dishonest grain sales (e.g. inaccurate quantities or grain quality). Collateral management companies provide inspection and quantity/quality assurance services to banks, rice exporters, traders, or rice importers to reduce risks along the supply chain and ensure that the grain purchased meets expectations. These companies also provide commodity inspection services and analytical tests to ensure particular specifications are met. Of the over 11 MMT of rice that are imported annually to the African continent, a "large part" of that volume is overseen by collateral management agreements[41] – but

[36] Olam Group. Thailand. Available at: http://olamgroup.com/locations/asia/thailand/

[37] Vimex Vietnam Import Export. Vietnam predicts firm contest for government to government rice sales in 2015. http://vimex.vn/detail/vietnam-predicts-firm-contest-for-government-%C2%ADto%C2%AD-government-rice-sales-in-2015-1555

[38] Customs data sourced from Interflour Viet Nam, 2016.

[39] Rice Exporters Association of Pakistan. http://reap.com.pk

[40] All India Rice Exporters Association. http://www.airea.net/member-directory

[41] Rutten, L. Opportunities for value chain finance in Africa's intra-regional food trade. Technical Centre for Agricultural and Rural Cooperation Working Paper 16/08 | January 2016. http://afraca.org/?wpfb_dl=310

the precise proportion is not known.

SGS SA is globally the leading provider of grain certification services and has 1,000 offices and laboratories in 120 countries. Other key inspection services companies are Bureau Veritas, Intertek Group, and Cotecna Inspection SA[42]. However, the only collateral managements companies referenced during field visits in countries were SGS SA[43] and DRUM Commodities[44].

For rice fortification, the potential significance of collateral management services is their capacity to test for nutrient requirements. Collateral management agreements are most often used by large international banks or traders[41], so it is likely that the services of these companies will be of greatest opportunities where supply chains are dominated by international rice traders.

Country Summaries

Grain availability

For the purposes of this report, over 75 g/c/d availability of rice is considered adequate quantities to consider fortification. However, rice varies in its dietary importance in each population. Of the countries assessed, six countries exceeded 200 g/c/d rice availability: Comoros, Liberia, Guinea-Bissau, Guinea, Madagascar, Sierra Leone, and Madagascar (Table 7). For the West African countries included in this report, rice is the dominant cereal grain (compared to wheat and maize) in every country except for Mauritania and Nigeria. In the six countries outside of West Africa, rice is the dominant grain in only two (Madagascar and Comoros); elsewhere wheat availability is higher than rice. Maize is the primary grain in only Nigeria, by 13 g/c/d over rice. Maize is an important secondary grain in several countries, especially for rural populations (Benin, Cabo Verde, Mali, Egypt). Similarly, although Mali is an exception in that sorghum and millet are important grains on par with rice, many countries reported low average availability of sorghum and millet, which are likely more commonly consumed in rural areas. Although not cereal grains, starchy tubers and plantains are important sources of carbohydrates in ten countries and in some countries they are rice substitutes when rice prices are high.

Without dietary consumption data to describe at least urban-rural differences, it is assumed fortifying wheat flour would provide greater coverage than rice in countries where wheat flour consumption greatly exceeds rice (i.e. Mauritania, Mauritius, Djibouti, Egypt). Rice fortification could target a subgroup population that consumes more rice than wheat flour but there is no consumption data to identify the beneficiary population. Compliance with mandatory fortification legislation in Mauritania, Djibouti, and Egypt is unclear, as fortification has reportedly halted in Egypt[45] and evaluations for Mauritania and Djibouti are not available.

<u>Fortification status and public health need for rice fortification</u>

All countries in West Africa, with the exception of Gambia and Guinea-Bissau, have mandatory wheat flour fortification legislation (Table 7). However it's likely wheat flour fortification has

[42] Hoovers Company Profile. http://www.hoovers.com/company-information/cs/company-profile.sgs_sa.36d09e96b51aef94.html

[43] Interviews indicated that importers use SGS SA in Benin, Côte d'Ivoire, Ghana, Guinea, and Sierra Leone.

[44] Interviews indicated that importers use DRUM Commodities in Benin, Ghana, and Liberia.

[45] FFI Database, Personal Communication with Quentin Johnson

limited nutritional impact, as in only two countries wheat flour availability is over 75 g/c/d (Cabo Verde and Mauritania), and countries would benefit from another fortified food vehicle with greater coverage. WHO flour fortification recommendations suggests that under 75 g/c/d, fortification of an additional food vehicle will provide greater public health benefit[46]. Modeling in other low wheat flour consumption countries (Viet Nam[47], Bangladesh[48]) has indicated even 30-50 g/c/d can deliver ~30%-50% of the WHO Recommended Daily Intake (RDI) for some nutrients (particularly folic acid and vitamin B12), but not for nutrients required in larger amounts, such as iron and zinc. Thus in the African countries below 75 g/c/d availability of wheat flour, rice fortification can provide greater coverage to improve public health.

Anemia prevalence estimates are not a direct indicator of nutrient status but as anemia can be caused by several nutrient deficiencies (e.g. iron, zinc, folate, etc.), high prevalence of anemia can suggest suboptimal nutritional status. WHO's 2011 estimates indicate that in all 19 countries anemia is a serious public health concern for young children; for women of reproductive age, anemia prevalence is a serious public health concern in 12/19 countries and a moderate public health concern in the remaining countries (Table 4).

[46] WHO, FAO, UNICEF, GAIN, MI, & FFI. Recommendations on wheat and maize flour fortification. Meeting Report: Interim Consensus Statement. Geneva, World Health Organization, 2009 (http://www.who.int/nutrition/publications/micronutrients/wheat_maize_fort.pdf)

[47] Laillou A, Berger J, Le BM, Pham VT, Le TH, et al. (2012) Improvement of the Vietnamese Diet for Women of Reproductive Age by Micronutrient Fortification of Staples Foods and Condiments. PLoS ONE 7(11): e50538. doi:10.1371/journal.pone.0050538

[48] Leyvraz M, et al. An Assessment of the Potential Impact of Fortification of Staples and Condiments on Micronutrient Intake of Young Children and Women of Reproductive Age in Bangladesh. Nutrients 2016 7, 9960–9971; doi:10.3390/nu7125511

Table 7: Rice, wheat, and maize availability* and % industrially milled by country (highlighted columns indicate mandatory fortification of the relevant cereal grain, FAO 2013[49].

	Rice (milled equivalent)			Wheat and products		Maize and products	
	G/c/d	*% industrially milled*	*% imported*	*G/c/d*	*% industrially milled*	*G/c/d*	*% industrially milled*
West Africa							
Benin	146	20%	66%	36	100%	110	Unknown
Cabo Verde	134	0%	123%	106	100%	102	Unknown
Côte d'Ivoire	174	8%	58%	57	98%	60	Unknown
Gambia	169	0%	56%	104	100%	48	Unknown
Ghana	88	11-23%	62%	40	100%	70	Unknown
Guinea	266	0%	13%	51	100%	26	Unknown
Guinea-Bissau	269	0%	41%	31	100%	28	Unknown
Liberia	260	<6%	33%	30	100%	0	Unknown
Mali	156	<6%	12%	34	100%	97	Unknown
Mauritania	133	Unknown	83%	276	95%	10	Unknown
Nigeria	77	12-24%	40%	57	100%	90	Unknown
Senegal	198	38-44%	105%	102	100%	51	Unknown
Sierra Leone	283	<7%	31%	24	100%	14	Unknown
Outside of West Africa							
Comoros	281	0%	100%	Unknown	100%	Unknown	Unknown
Djibouti	122	0%	129%	326	100%	3	Unknown
Egypt	108	100%	3%	402	100%	173	Unknown
Gabon	94	0%	106%	172	100%	45	Unknown
Madagascar	281	1%	16%	25	100%	49	Unknown
Mauritius	142	Unknown	84%	312	95%	8	Unknown

G/c/d, grams per capita per day

*Definitions of foods included under FAO categories of rice, wheat and products, maize and products include flours as well as derivative products (e.g. pastas). Detail can be found at: Food Balance Sheets – Definitions and Standards, http://www.fao.org/faostat/en/#data/FBS

[49] Proportions calculated using FAO Food Balance Sheets 2013. Mandatory legislation status data from FFI Database.

Preferences for rice types and quality

Preferences for rice across countries are not uniform, differing by both rice quality and varieties. Quality can refer to percent of broken kernels[50], homogeneity, and cleanliness (e.g. stones, chaff, etc). For varieties rice is categorized by length (long, medium, or short grain), scent (basmati and jasmine rice varieties are long grain but typically described as fragrant or aromatic rice), and color (e.g. red rice, brown rice). Parboiled rice is milled rice that undergoes a steaming and drying process while still in the husk, resulting in greater starch gelatinization[51]. Any kind of rice can be parboiled; outside of Africa parboiled rice is commonly consumed in parts of India, Pakistan, Sri Lanka, and Bangladesh[52].

In general, the more price sensitive the consumer, the greater the market for rice with a high percentage of broken kernels. In Gambia, Guinea-Bissau, Liberia, Mauritania, Senegal, and Sierra Leone, the preference is for 100% broken rice, likely both due to low price and traditional use in traditional dishes. Although parboiled rice is consumed by subpopulations in most countries, Nigeria is the only country that exclusively prefers parboiled rice.

Fortified kernels (coated or extruded) can be produced to meet most rice shapes and sizes. Acceptability studies in Brazil and Asia of fortified rice using extruded kernels show either preference for fortified rice or inability to identify fortified rice from unfortified rice[53,54,55].

Table 8 details market preferences for rice by country.

Table 8: Market preferences for rice varieties and quality, by country[56]

West Africa	
Benin	• *Primarily an importer of high-quality white rice, brokens ranging from 5%-25%.* • *High-quality white and aromatic rice are preferred in urban areas.* • *Some consumers also prefer parboiled rice, especially in rural areas* • *Imported parboiled rice likely re-exported to Nigeria*
Cabo Verde	• *Market preference for medium grain white rice from Thailand, proportion of brokens unknown. No rice grown in Cabo Verde.*
Côte d'Ivoire	• *The overall market is dominated by 15% broken white rice, followed by 50% brokens. High quality 5% aromatic rice is considered only 2% of the market.* • *About half of rice imports are aromatic, from Thailand and Viet Nam.*

[50] Percentages for broken rice are typically 5%, 10%, 25%, 50%, 75%, and 100%

[51] Rice Hub, Parboiling. http://www.ricehub.org/RT/post-harvest/parboiling/improved-parboiling-technologies/usd-parboiling-technology/

[52] Biswas SK et al. Laboratory Parboiling Procedures and Properties of Parboiled Rice from Varieties Differing in Starch Properties. Cereal Chem. 65(5):417-423. Accessed at: http://www.aaccnet.org/publications/cc/backissues/1988/documents/65_417.pdf

[53] Beinner MA, et al. Sensory evaluation of rice fortified with iron. Ciênc. Tecnol. Aliment., Campinas, 30(2): 516-519, abr.-jun. 2010

[54] Moretti D, et al. Development and Evaluation of Iron-fortified Extruded Rice Grains. Journal of Food Science. Vol. 70, Nr. 5, 2005

[55] Tran KV, et al. Organoleptic qualities and acceptability of fortified rice in two Southeast Asian countries. Ann. N.Y. Acad. Sci. ISSN 0077-8923

[56] Benin, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Nigeria, Senegal, Sierra Leone include some observations adapted from Rutsaert et al, Consumer Preferences for Rice in Africa (in Realizing Africa's Rice Promise). Available at: http://www.africarice.org/publications/rice_promise/Chap23%209781845938123.pdf

	• *Local rice is mostly consumed in rural areas.* • *Limited local parboiling near the border with Guinea.*
Gambia	• *Price-conscious market; consumer preference is for 100% broken rice.* • *Some 25% broken white rice is imported as well.* • *Local rice is considered premium and more expensive than imported*
Ghana	• *Rice is not an essential staple food. Consumer preference is for high-quality white and aromatic rice (5% brokens). Aromatic rice is considered 80% of the market and sold at a premium and Ghana is Africa's largest importer of aromatic rice.* • *There is ~10% demand for 100% broken rice used specifically for traditional dishes* • *Rural households parboil rice, particularly in the north* • *Imported parboiled rice serves the Muslim population, ~1% of the market.*
Guinea	• *Imports are at least 50% low-quality 100% broken rice but parboiled and 25% broken rice is also consumed in the urban market.* • *Rural consumers prefer locally parboiled rice.* • *Some varieties of local rice are popular and sold at a premium to imported rice.*
Guinea-Bissau	• *Market preference for 100% broken rice*
Liberia	• *Domestic rice parboiled at household or village level* • *Market dominated by 100% brokens and 50% brokens, with some 5% broken demand from middle-high income consumers.* • *Past reports[57] of 80% preference for round-grain Chinese rice and low-quality parboiled rice*
Mali	• *Primarily domestic rice consumed; local rice is ~40% broken due to poor milling.* • *Premium varieties of local rice (e.g. Gambiaka) more expensive than imported rice.* • *Imports include 100% brokens as well as high quality aromatic rice*
Mauritania	• *Consumer preference is for 100% broken rice, both aromatic and white.*
Nigeria	• *In northern Nigeria the preference is for rice flour (97% share), as opposed to grain. In the south, the preference is for high-quality parboiled, mostly imported rice.*
Senegal	• *Consumer preference is for 100% broken rice, both white and aromatic, but there is approximately a 30% market for rice with 50% or less brokens.* • *In rice-production areas, local rice is preferred. In urban areas, consumers prefer imported rice; aromatic 100% broken rice is preferred in Dakar*
Sierra Leone	• *Price-conscious market, importers report that 75% of market is now 100% brokens*
Outside of West Africa	
Comoros	• *Rice imported by government agency (Onicor) so availability and price of government-to-government bids may overrule market preference for rice. Current contract is for Pakistani rice with 15% brokens, but past reports of Vietnamese rice.* • *Higher income households purchase Pakistani basmati rice*
Djibouti	• *White milled rice and red Belem rice; unknown broken percentage.*
Egypt	• *Domestically grown rice is medium-grain Japonica varieties.*
Gabon	• *White milled rice, unknown broken percentage or varieties.*
Madagascar	• *Domestic rice is the main share of national consumption. Several unique varieties of rice in Madagascar are grown* • *Imported rice is white milled rice from India and Pakistan*
Mauritius	• *Primary market is for white milled rice, with a smaller demand for brokens (~22%)*

[57] Alavi S et al. Eds. Rice Fortification in Developing Countries: A Critical Review of the Technical and Economic Feasibility. April 2008. A2Z Project. Available at: https://www.spring-nutrition.org/sites/default/files/a2z_materials/508-food-rice-fortification-report-with-annexes-final.pdf

Domestic rice production and rice imports

All but four of the 19 countries have domestic production of rice. Comoros and Mauritius grow token amounts of rice – 1,000 MT annually or less –while Cabo Verde and Djibouti do not grow any. For these countries, imported rice is the sole opportunity for rice fortification.

The total share of imported rice in a country's rice supply can indicate how reliant a country is on imports. Table 9 ranks countries according the proportion of the rice annual supply provided by imported rice, by the import rice data source (FAO or USDA)[58,59]. As the FAO data is older than USDA by three years but FAO remains an important global source for food availability, both are presented and compared. As the directional arrows demonstrate, the two data sources are not completely aligned regarding imported rice share.

According to both sources, imported rice does not provide a significant portion (less than 25%) of the rice supply for Mali, Egypt, and Madagascar. In these countries, the success of rice fortification will depend primarily on the feasibility of fortifying domestically grown rice.

On the other extreme, the opportunity for rice fortification is for imported rice in countries that import close to 100% of the rice supply (Senegal, Cabo Verde, Comoros, Djibouti, Gabon).

Table 9: Imported rice share of total rice available, by import data source[1] [60]

Import share of total rice available (FAO 2013*)		Import share of total rice available (USDA 2016)	
West Africa			
Mali	13%	Mali	17%
Guinea	32%	Guinea	24%
Liberia	33%	Nigeria	38%
Nigeria	40%	Sierra Leone	49%
Guinea-Bissau	44%	Côte d'Ivoire	51%
Sierra Leone	46%	Benin	63%
Gambia	56%	Ghana	67%
Côte d'Ivoire	57%	Mauritania	68%
Ghana	78%	Liberia	82%
Mauritania	103%	Guinea-Bissau	89%
Cabo Verde	135%	Senegal	96%
Senegal	140%	Gambia	112%
Benin	145%	Cabo Verde	No data
Outside of West Africa			
Egypt	1%	Egypt	-5%
Madagascar	16%	Madagascar	0%

[58] At least three sources exist for imported rice data – FAO, USDA, and UN Comtrade, and correspondingly the percent share of imported rice differs depending on the import data source. FAO and USDA data are compared in Table 9 because both have attempted to take in account net imports; UN Comtrade does not.

[59] Because FAO data is three years behind USDA for almost all countries, the mismatches between the other countries could be due to changes in import volumes that FAO data does not reflect, rather than a true difference in the annual data.

[60] Calculated: MMT of rice imports annually (either FAO or USDA reported data)/Total MMT rice used annually in country calculated as ([Population*[per kg/yr rice availability])/1000 kg))

Mauritius	95%	→	Mauritius	97%
Comoros	100%		Comoros	Data not available
Gabon	136%		Gabon	Data not available
Djibouti	253%		Djibouti	Data not available

*2013 data only available for Côte d'Ivoire, Madagascar, Nigeria, and Senegal.
Arrows compare the FAO and USDA data for imported rice shares in each country. Green arrows indicate matches between the two datasets while Purple arrows indicate discrepancies.

Domestic milling industry

The viability of rice fortification in domestic channels relies on the capacity of the local rice milling industry. Rice fortification at village or small-scale (defined at less than 5 MT/hr of paddy[61]) mills is typically less efficient than fortification at large industrial mills that can take advantage of economies of scale. Enforcement of fortification is also difficult with high numbers of small mills to regulate[62]. Financially, fortification requires an initial capital investment (e.g. blending machine for kernels) and the cashflow for ongoing purchase of fortified kernels to blend. Larger mills are more likely to have the resources for investments, quality control and quality assurance training, and stable fortified kernel supply.

Table 10 shows the *potential* industrial milling capacity in the 19 African countries if all existing rice mills operated at 100% utilization. Highlighting the potential milling industry capacity indicates what the current milling industry might be able to produce if required to scale-up for domestic rice fortification. Actual production of industrially milled rice in these countries is either non-existent or very low – with the exception of Egypt, where an estimated 100% of domestic rice is milled industrially due to its role as a key rice-exporter in the region. Nigeria, Ghana, and Benin come closest to being able to mill approximately 50% of the domestically produced rice in its country; Senegal's capacity varies widely depending on data source. The Government of Côte d'Ivoire has ambitious goals in the near future to invest in modernized milling infrastructure that could add approximately 650,000 MT/year of paddy rice processing capacity (estimated 400,000 milled rice equivalent). However, even then this would handle less than a third of the country's domestic production (1.4 MMT). Hand pounding of rice in remote areas or toll milling in village mills is still overwhelmingly the practice for the majority of the domestic rice grown in the assessed countries.

Based on the current state of industrial milling, it is unlikely that comprehensive domestic fortification of rice is possible in the immediate future in any of the countries assessed. The public health benefits of rice fortification will be out of reach for consumers of domestically grown rice – i.e. rural populations growing rice for self-consumption or locally traded rice.

The estimated domestic industrial milling capacity is presented by both FAO and USDA data because the proportion differs depending on the estimated milled rice production in a given country.

[61] Alavi S et al. Eds. Rice Fortification in Developing Countries: A Critical Review of the Technical and Economic Feasibility. April 2008. A2Z Project. Available at: https://www.spring-nutrition.org/sites/default/files/a2z_materials/508-food-rice-fortification-report-with-annexes-final.pdf

[62] Zimmerman SL, et al. Mandatory policy: Most successful way to maximize fortification's effect on vitamin and mineral deficiency. Indian Journal Of Community Health / Vol 26 / Supp 02 / Dec 2014

Table 10: *Potential* domestic industrial milling capacity, by domestic production data source (FAO or USDA)[63]

Country	Capacity of industrial mills to mill domestic rice (FAO 2013)	Capacity of industrial mills to mill domestic rice (USDA 2016)
W. Africa		
Cabo Verde	Only imported rice	Only imported rice
Guinea-Bissau	0%	0%
Mauritania	0%	0%
Guinea	1%	1%
Liberia	6%	6%
Mali	7%	6%
Côte d'Ivoire	8%	6%
Sierra Leone	13%	16%
Gambia	39%	30%
Ghana	41%	52%
Benin	43%	40%
Nigeria	46%	54%
Senegal	89%	38%
Other AFRO		
Madagascar	0%	0%
Mauritius	0%	0%
Egypt	100%	100%
Comoros	Only imported rice	Only imported rice
Djibouti	Only imported rice	Only imported rice
Gabon	Only imported rice	Only imported rice

Mode of imports and storage capacity at port

Rice is imported into Africa in one of three ways: 1.) In containers, i.e. bagged in shipping containers (a typical 20-foot container holding 20-24 MT of grain). 2.) Break-bulk, i.e. pre-bagged rice shipped in the holds of shipping vessels. 3.) Bulk, i.e. loose grains.

The mode of rice imports is relevant if rice is intended for fortification after arriving in the destination country. For rice that is already bagged, fortification at destination will involve the additional logistics and costs of bag ripping and re-bagging after blending. Fortifying rice at destination will favor bulk shipments, but bulk imports of rice is the majority practice in only a few countries (Gambia, Guinea-Bissau, Nigeria, Senegal, and Sierra Leone). Mode of imports is unknown for all countries that were not included in field visits.

[63] FAO Production 2013 data available for Nigeria, Senegal, Madagascar, and Côte d'Ivoire

Table 11: Import practices for cargo rice, storage capacity at port, and bag sizes at import or bagging at port

	Mode of imports, %			Storage capacity at port	Bag sizes
Country	*Containers*	*Break-bulk*	*Bulk*		
West Africa					
Benin	29	69	2	11,000 MT silo storage, 100,000 m^2 warehouse storage, 15,000 m^2 container park, 60,000 m^2 open space storage. Free-trade zone storage for Mali, Niger, and Burkina Faso. Only one large importer stores rice in the port's free-trade zone	50 kg
Cabo Verde	Unknown	Unknown	Unknown	Santiago port: 12,500 MT Sao Vicente: 2,100 MT Fogo: 3,000 MT	Unknown
Côte d'Ivoire	0	90	10	Abidjan: 480,000 MT (container capacity) Three importers report warehouse storage at port, with plans to develop bulk storage silos with 720,000 MT/yr capacity	50kg 25kg
Gambia	11	29	60	170,000 MT (container capacity)	50kg
Ghana	18	66	16	Tema: 10,000 m^2 (warehousing capacity) Takoradi: 7,800 m^2 (warehousing capacity)	50kg 25kg
Guinea	0	90	10	192,000-360,000 MT (container capacity) 90,000 m^2 (warehousing capacity)	50kg 25kg
Guinea-Bissau	15	0	85	7,815 m^2 but reportedly under repair	50kg 25kg
Liberia	5	95	0	Monrovia: 240,000 MT (container capacity, under construction) At least three importers have port warehouse storage. One importer's storage capacity is 65,000 MT	50kg 25kg
Mali	Mali is landlocked – bagged rice is transported via land borders. Rice destined for Mali arrives break-bulk or bulk, and bagged at port. There is no port storage.				50kg 25kg
Mauritania	Unknown	Unknown	Unknown	Nouakchott: 1.2 MMT (container capacity) 12,205m^2 (warehousing capacity) Nouadhibou: Unknown	Unknown
Nigeria	5	24	71	Lagos: 480,000 MT (container capacity) Port Harcourt: Unknown	50kg 25kg
Senegal	20	0	80	40,000 m^2 (warehouse)	25kg
Sierra Leone	4	0	96	115,000 MT (container capacity One importer's storage capacity is 60,000 MT; across multiple ports, 14,000 m^2	50kg
Outside of West Africa					
Comoros	100	0	0	Moroni: 84,000 MT (container capacity); 2,000 m^2 (warehouse) Mutsamudu – Anjouan: 450,000 MT (container capacity)	25kg 10kg
Djibouti	Unknown	Unknown	Unknown	20,000 MT (WFP) 6900 m^2 (warehouse)	Unknown
Egypt	Unknown	Unknown	Unknown	86,136 m^2 (warehouse)	Unknown
Gabon	Unknown	Unknown	Unknown	60,000 MT (container capacity)	Unknown
Madagascar	100	0	0	Toamasina: 120,000 m^2 (open air) Diego Suarez: 800 m^2 (container only) Mahajanga: 2,300 m^2 (warehouse) Taolagnaro: 2,000 m^2 (warehouses)	50kg
Mauritius	Unknown	Unknown	Unknown	70,000 m^2 (warehouse)	Unknown

Potential population coverage

Approximately 400 million people live in the 19 African countries assessed (Table 12). Although each of these countries are considered to consume the minimal amount of rice to consider rice as fortification vehicle, FFI calculated an estimated "reachable population" in each country because it is not expected that every single person in the country will benefit from rice fortification:

1.) Rice is unlikely to be a staple food for everyone in all of these countries; in many countries nationally representative dietary consumption data is not available, so only average food availability is reported. As such, it's expected that the average per capita rice available in each country will not be uniformly distributed across the population – some people will consume more rice than the average while others will consume less than the average. Other carbohydrate sources, such as wheat flour, maize, sorghum, millet, and starchy crops are also still an important source of calories in several countries.

2.) In all but four countries, rice is domestically produced. But as Table 10 showed, only Egypt is considered to have a domestic rice milling industry that could potentially be able to fortify. In the rest of the countries, populations consuming locally grown rice that is not industrially milled is not considered "reachable" by fortified rice.

Table 12 estimates the proportion of the population that fortified rice could potentially reach. Understanding the "reach" of a fortified vehicle identifies which populations are most likely to benefit from consuming fortified foods. Green countries are considered rice fortification opportunities – fortified rice could be consumed by a certain proportion of the population and as such expected to provide a public health impact in that population. However, green does not automatically mean that rice fortification would be easily implemented – in many countries strong caveats threaten the implementation of rice fortification.

Twelve countries are considered opportunities for rice fortification. Of these twelve, 100% of rice is imported in four countries (Cabo Verde, Comoros, and Djibouti), and thus it is assumed that the entire population could benefit from rice fortification[64]. This may be an overestimation if rice consumption is not distributed evenly across the population, which could be the case in a country such as Djibouti, where wheat flour is the primary cereal grain. In the remaining nine countries, rice fortification is only expected to reach the urban populations, where imported rice is primarily consumed over domestically grown rice. Collectively, the reach of these green opportunity countries is 130 million people, or 32% of the 400 million living in these countries.

Four countries (Guinea, Mali, Sierra Leone, and Madagascar) are not considered opportunities for rice fortification because imported rice quantities are low relative to domestic rice production and the domestic rice milling industry cannot yet support fortification. In these countries, the urban population is expected to consume domestically grown rice in addition to imported rice.

In three countries (Mauritania, Egypt, and Mauritius), further information is needed to make a conclusion regarding the opportunities for rice fortification. These countries were not prioritized for field visits given that wheat flour is the staple food in each country. In Mauritania and Egypt, more information regarding the domestic rice milling industry is needed. Even though Egypt is reported to have a modernized rice milling industry, this information came from secondary sources and requires confirmation. In Mauritius, it may be likely that rice fortification is an option since low quantities of rice is grown in the country. But since no fieldwork took place there, this report cannot comment on the rice import industry in Mauritius.

[64] Although Gabon also imports 100% of its rice, since rice is not it's primary staple food it's only estimated that the urban population will be reached through imported rice.

Table 12: Population reach of potential rice fortification opportunities

	Population	% Urban	Potential reach	Justification
W. Africa				
Benin	10,320,000	44	4,540,800	Fortification of imported rice potentially feasible; could reach the 44% urban population (44% of population).
Cabo Verde	490,000	66	490,000	Fortification of imported rice is potentially feasible; because no rice is grown or milled domestically and rice is the primary staple grain, fortification would reach the entire population.
Côte d'Ivoire	20,320,000	54	11,013,440	Fortification of imported rice is potentially feasible and would reach the urban population (44% of population).
Gambia	1,840,000	60	1,104,000	Fortification of imported rice is potentially feasible and would reach the urban population (60% of population).
Ghana	25,900,000	54	13,986,000	Fortification of imported rice is potentially feasible and would reach the urban population (54% of population). There may be limited coverage in rural areas that consume imported rice.
Guinea	11,750,000	37	--	No. Only 37% of the population is urbanized and this population also consumes both imported and domestically grown. Domestic rice is hand-pounded and is the majority of rice consumption.
Guinea-Bissau	1,700,000	49	838,100	Fortification of imported rice is potentially feasible and would reach the urban population (49% of population). Rice imports are closely tied to the cashew export industry on a barter basis, which may complicate the costs of fortification. Some coverage in rural areas that consume imported rice.
Liberia	4,290,000	50	2,132,130	Fortification of imported rice is potentially feasible and would reach the urban population (50% of population).
Mali	15,300,000	40	--	No. Only 40% of the population is urbanized and this population also consumes both imported and domestically grown. Domestic rice is small-milled and is the majority of consumption.
Mauritania	3,890,000	60	--	Domestic milling information required for a conclusion but expected low impact of rice fortification. Imported rice and domestically produced rice are approximately equal shares and wheat flour is the primary staple.
Nigeria	173,600,000	48	86,800,000	Success of rice fortification is highly dependent on the ability to regulate cross-border trade. If all imports were fortified (including illegal imports) fortified rice could reach the urban population (48% of population). Domestic rice milling capacity is growing but at most 30% of rice is industrially milled.
Senegal	14,130,000	44	6,174,810	Fortification of imported rice is potentially feasible and would reach the urban population (44% of population). There may be limited coverage in rural areas that consume imported rice. Fortification of domestic rice production could be possible in the short-term future, as the milling industry is growing quickly.
Sierra Leone	6,090,000	40	--	No. Small imported rice quantities. Domestic rice is small-milled and is the majority of the consumption.
Outside of West Africa				
Comoros	735,000	28	735,000	Fortification of imported rice is potentially feasible. Because almost no rice is grown or milled domestically and rice is the primary staple grain, fortification would reach the entire population.
Djibouti	872,000	77	872,000	Fortification of imported rice is potentially feasible because no rice is grown or milled domestically. However, wheat flour is the primary staple.
Egypt	82,060,000	43	--	Additional information necessary to make a conclusion. Rice fortification depends on the domestic rice milling industry, which is reportedly 100% industrial milling. Imported rice is only a small proportion of rice consumed. However, wheat flour is the primary staple.
Gabon	1,672,000	87	1,457,984	Fortification of imported rice is potentially feasible and would reach the urban population (87% of population).
Madagascar	22,920,000	35	--	No. Only 35% of the population is urbanized and this population also consumes both imported and domestically grown. Domestic rice is small-milled and is the majority of consumption.
Mauritius	1,296,000	40	--	Additional information necessary to make a conclusion. Rice is primarily imported and could be an opportunity but wheat flour is the primary staple.
Total Population	**399,175,000**	**Potential population coverage**	**130,144,264**	

Rice export origins and quantities

According to UN Comtrade for 2014, 83 countries exported rice to the 19 African countries of interest in this report. India was the greatest exporter, with 2.8 MMT of rice, Thailand second at 2.2 MMT. Table 12 shows the rice origins for each country exporting at least 11,000 MT to African countries. Comoros is the only country that does not import rice from Thailand. Viet Nam and Pakistan are the third and fourth largest rice suppliers, but are each only a quarter of the volumes that Thailand and India export. Latin America (Uruguay and Brazil) and the United States are the remaining key rice exporting countries. Several countries listed by UN Comtrade are likely rice re-exporters as these countries or territories are not large rice producers (e.g. United Arab Emirates[65], Antigua and Barbuda, Singapore, Italy, Hong Kong, and Switzerland).

How much rice would need to be fortified if all 130 million people identified in Table 12 were reached? The total sum of rice imported into these 19 countries is 7.2 MMT. Excluding the countries labeled red and orange in Table 9 because they are not considered opportunities or they are unknowns, the remaining rice imported into Africa is 5.7 MMT. Referring to Table 14, fortifying 5.7 MMT of rice would require 28,600 MT of fortified kernels (1:200 blending ratio).

Coated kernels are less expensive to create than extruded kernels. Discussions from one coated kernel manufacturer in the US suggested willingness to invest capital for a coated kernel production facility abroad if adequate demand existed (50,000 MT of fortified kernels annually). If this is accurate, then this plant would run maximally at 52% capacity if all countries in Table 12 demanded kernels. There could also be shipping challenges with one coated kernel facility serving the entire African continent. At present, there is only one commercial coated kernel producer – for future coated kernel producers it will be important to understand manufacturing demand of other coated kernel producers using high quality rinse-resistant technology.

Countries that export rice are likely to have an advantage in access to raw material (broken rice or rice flour) compared to the destination countries, many of have limited access to high-quality paddy rice for domestic milling.

Based on the volumes exported by the countries identified in Table 12, Table 13 identifies potential geographic locations for fortified kernel production as well as extrusion line capacity required to fortify the quantities exported to the 12 opportunity countries. Countries exporting quantities of rice too small to justify domestic fortified kernel production may find that importing is more cost-effective. For example at 1:200 blending a minimum demand of 360,000 MT of fortified rice is required for a fortified kernel extrusion line with 0.25 MT/hr capacity.

Table 12 shows that only five opportunity countries in Africa reach this minimum while four countries (India, Thailand, Pakistan, Viet Nam) could justify a domestic fortified kernel extrusion line of 0.25 MT/hr or greater. A small country such as Cabo Verde requiring rice fortification would only result in small increase in production demand globally for fortified kernels. Minimizing rice fortification costs for small countries with low import quantities will depend on their larger neighbors to push the demand for fortified kernel production.

[65] Wam. UAE is top global rice re-exporter by far. September 16, 2010. Accessed at:http://www.emirates247.com/business/economy-finance/uae-is-top-global-rice-re-exporter-by-far-2010-09-16-1.291440

Table 13: Bilateral rice imports by rice import origin (MT), 2014/2015[66]

Country	*India*	*Thailand*	*Pakistan*	*Viet Nam*	*Brazil*	*USA*	*Uruguay*	*Senegal*	*Myanmar*	*Others*	Total
Benin	589,558	614,914	17,718	26,908	13,860		8,100	251	0	126,463	1,397,771
Cabo Verde	20	18,361	24	1,820	6,816	3	2,597	4	0	631	30,275
Comoros	0	0	80,000	0	0	0	0	0	0	0	80,000
Côte d'Ivoire	207,531	356,776	65,697	225,525	0	14,210	0	0	74,298	8,564	952,601
Djibouti	148,575	285	31,255	0	0	68	0	0	0	118	180,301
Egypt	29,516	5,856	639	0	0	42	0	0	0	88	36,141
Gabon	383	68,408	0	0	0	0	0	0	0	56	68,847
Gambia	38,374	31,390	27,611		22,796	67	9,627	66	0	9,938	139,871
Ghana	62,063	126,630	8,351	334,555		106,248	0	0	3,126	3,362	644,334
Guinea	381,867	16,234	4,824	0	0	3,264	0	1,460	0	47	407,696
Guinea Bissau	4,595	11,625	37,785	0	375	0	4,950	7,662	0	999	67,991
Liberia	260,368	1,622	337	0	0	5,285	0	0	0	3,511	271,123
Madagascar	159,696	6,802	193,419	4,534	0	0	0	0	0	1,544	365,996
Mali	3,388	309	53	0	16,739	0	0	94,862	0	30	115,381
Mauritania	10,185	37,577	70,861	455	29,863	2,129	0	624	0	13,534	165,230
Mauritius	47,258	2,644	6,737	60	0	23	0	0	0	370	57,093
Nigeria	127,210	644,131	27	0	11,072	75	0	0	0	583	783,098
Senegal	685,482	240,113	11,174	545	50,082	18,445	14,422	0	0	91,095	1,111,357
Sierra Leone	44,567	41,808	68,829	0	74,528	0	76,871	0	0	4,083	310,686
Total	**2,800,636**	**2,225,486**	**625,341**	**594,401**	**226,131**	**149,860**	**116,567**	**104,929**	**77,424**	**265,016**	**7,185,790**
Only green countries	2,124,158	2,114,255	279,978	589,352	105,002	144,402	39,696	7,983	77,424	245,319	**5,727,569**
Without Nigeria	1,996,948	1,470,124	279,951	589,352	93,929	144,327	39,696	7,983	77,424	244,737	4,922,823

[66]UN Comtrade 2014 import quantities were triangulated with FAO, USDA, and Key Consulting estimates (via importer interviews). Where UN Comtrade aligned with both FAO and USDA, UN Comtrade quantities were used because by-origin-country quantities were available. If UN Comtrade import quantities were not available for a given country then reported export quantities from UN Comtrade 2015 were used instead (Djibouti, Egypt, Gabon, Guinea, Guinea-Bissau, Liberia, Mali, Nigeria, Sierra Leone).For Ghana, UN Comtrade 2013 was the most recent data available. Only countries representing 1% or greater of total rice exports are presented.
Abbreviations: MT, metric ton; USA, United States of America

Table 14: Hypothetical fortified kernel extrusion capacity if all rice considered an opportunity in Africa were fortified, by export country quantities*

Origin countries	Rice exported (MT)	Extrusion lines required to fortify export quantity
India	2,124,158	One 1 MT/hr line at 100% utilization One 0.5 MT/hr line at 95% utilization
Thailand	2,114,255	One 1 MT/hr line at 100% utilization One 0.5 MT/hr line at 94% utilization
Pakistan	279,978	One 0.25 MT/hr line at 78% utilization
Viet Nam	589,352	One 0.5 MT/hr line at 82% utilization
Brazil	105,002	One 0.25 MT/hr line at 29% utilization
USA	144,402	One 0.25 MT/hr line at 40% utilization
Uruguay	39,696	Collectively fortifying rice from minor rice exporting countries could require one 0.25 MT/hr line at 100% utilization
Senegal	7,983	
Myanmar	77,424	
Others	245,319	

*Assuming 1:200 blending ratios; utilizations would differ depending on the extrusion line capacity.

Options for Points of Fortification

Rice imported to Africa can be fortified in two locations:

1.) Country of rice origin or re-export (i.e. at re-processors or millers that pack for export)
2.) Destination (i.e. after arrival into a country).

Each option has advantages and disadvantages that should be considered when identifying where rice fortification should occur (Table 15). Likely, suitable options will differ for each country depending on their supply chain for fortified rice.

For option 1, fortifying rice in the origin countries could allow for a high level of operational consolidation because the majority of rice is coming from a limited number of countries (India, Thailand, Pakistan, Viet Nam). By producing their own fortified kernels, manufacturers in these countries would benefit from ready access to raw material. Alternatively rice millers could also import kernels from another international source for blending.

For option 2, fortifying rice after importation (using imported or domestically-produced kernels) would allow rice importers greater flexibility and nutrient longevity (particularly if importers hold stocks for several months), but may also require greater regulatory resources from the local government than monitoring imported rice at a centralized location, such as seaports or key land borders.

Where fortification occurs within the supply chain affects at what stage a regulatory agency should monitor for fortification to meet national standards. If fortified rice is imported fortification should be enforced at ports or land borders via sampling and documentation checks. But if rice is blended after arrival, then regulatory monitoring of the blending facility is necessary.

Table 15: Considerations for selecting point of fortification in supply chain

Point of Fortification	Advantage	Disadvantage
In rice origin country	• For countries with limited land-border imports, regulatory monitoring at ports is centralized. • Rice exporters are likely consolidated and modern mills or re-processors with resources for fortification. • India and Thailand export 70% of the rice (5 MMT) imported into the 19 countries; fortified kernel production could represent centralized production in these two countries. • Ready source of raw material (broken rice/rice flour).	• Fortified kernels typically have a "best before" shelf life of 12 months. Shipments of rice spend on average 3 months traveling from Asia to Africa. If rice is stored after arrival, it is possible that fortified rice will not be consumed in time for maximum impact on health. • Origin countries can change quickly depending on global rice prices. Investing in local kernel production could be risky if demand is not consistent.
At destination country a.) Domestic kernel production	• Potentially less waste and loss compared to overseas transportation • Offers greatest nutrient longevity • Non-fortified rice can be stored and blended into fortified rice as needed	• Requires investment in local kernel production • Requires greater regulatory capacity to audit and inspect kernel production facilities • Limited availability of raw material in most countries • Few countries consume volumes of rice large enough to justify an investment in kernel production
At destination country b.) Imported kernels for blending	• Non-fortified rice can be stored and blended into fortified rice as needed	• Requires investment in local blending capabilities • Requires greater regulatory capacity to audit and inspect domestic blending facilities • Requires each importer to have access to a centralized blending facility • Unfortified rice that arrives bagged already will have to be opened and re-bagged, adding additional expense • Potential nutrient loss in the fortified kernels from shipping and storage time

Barriers to rice fortification

Although fortified rice is considered a potential opportunity for 12 of the countries assessed, important implementation barriers must be addressed prior to consideration for a mandatory rice fortification policy. Considering all 12 countries, the following shared barriers are:

Regulatory monitoring at porous land borders and seaports

Rice is considered an essential commodity for food security and stability, in both the importing countries in Africa and rice production countries in Asia. As such, several countries have rice policies that are constantly in flux – duties are raised or lowered depending on global rice prices or expected deficiencies in the domestic rice crop. These policies result in opportunistic rice trade with quantities dependent on how favorable or unfavorable the given rice policy may be at the moment.

In the region, Benin's rice trade with Nigeria has enormous implications for the feasibility of rice fortification. With its demand representing 20% of the total rice imported into the 19 countries, rice fortification in Nigeria would immediately create a demand for fortified kernels that would most likely require a new fortified kernel production line in India or Thailand. However, it's estimated that 70% (850,000 MT) of the rice imported into Benin's Port of Cotonou in 2014 was illegally destined for Nigeria due to more favorable rice import duties in Benin. That Nigerian officials overlook the smuggling of almost one-third of the national rice consumption raises the question whether enforcement of fortified rice would occur if mandated. If only Benin required rice fortification, Benin would be required to differentiate whether rice is intended for re-export or the domestic market. There is currently no official evidence that this documentation occurs. Enforced universal fortification of rice entering Benin could also redirect illegal imports from Benin to one of Nigeria's other neighbors if the financial incentive to avoid fortification was adequate.

Without strong regulatory monitoring of land borders, mandatory rice fortification in one country could lead to smuggling of cheaper, non-fortified rice from a neighboring country.

Theoretically, enforcing rice fortification as it enters seaports is more feasible than policing large stretches of land borders. Most of the countries assessed have one major international port where the bulk of rice imports arrive. However, in the few countries with anecdotal information, regulatory monitoring at ports by Customs appears inadequate. Sources in Madagascar estimate that as much as 30% of claimed rice imports are falsified to take advantage of the 0% duty for rice imports[67]. Strong regulatory monitoring by inspectors at port is integral to ensuring the success of a rice fortification program in the 12 opportunity countries.

Government interventions: rice-self sufficiency policies and price interventions

For several reasons (increased oil costs, fear of crop shortages, etc.), a global rice crisis occurred in 2008, during which the global price of rice more than tripled in less than four months[68]. As rice-producing countries restricted their exports to protect their own rice supply, countries

[67] Personal communication from Seaboard Mills to David McKee, Key Consulting. 2015

[68] Cambell R, et al. United States Agency for International Development. Global Food Security Response: West Africa Rice Value Chain Analysis. October 2009

dependent on rice imports were hit hard by the rapid price increase. Since 2008, several countries in Africa (particularly Senegal, Benin, Mali, Côte d'Ivoire, Nigeria, and Sierra Leone) have put in place national rice self-sufficiency policies intended to reduce the national dependence on imported rice.

Yet no country in this report, with the exception of Egypt, could currently fortify its domestic supply of rice, due to either a nonexistent rice milling industry or dominant reliance on non-industrial milling of rice. It is not enough for countries to increase production. Rapid investment in paddy rice storage and domestic rice milling would also be necessary to accommodate increased production. Indeed, the governments of Senegal, Nigeria, and Côte d'Ivoire set deadlines for the end of rice imports – deadlines that have passed with no end to rice imports due to insufficient production. With the exception of Mali and possibly Côte d'Ivoire due to its rapid recent production increases, where production is almost 90% of domestic requirements, none of the countries included in this report are on their way to self-sufficiency in the near future.

A repeated theme in several of these countries was that domestic rice cannot compete with imported rice on quality. Sources reported preferring imported rice for cleanliness even if they preferred the taste and freshness of domestically grown rice. Inefficient domestic rice mills without sorting or de-stoning equipment cannot compete on quality with rice milled in large industrial facilities in Asia. Although private sector investment in rice milling is growing in countries such as Senegal and Nigeria, several sources also reported hesitance to invest due to government-provided minimum support prices or constantly changing rice import and export policies that affect the supply of rice.

Conclusion: Regional activity required for scale

Decreasing the cost of rice fortification from its current $20/MT price tag (estimated price for extruded kernels) requires greater availability and competition for fortified kernels. A 2014 estimate suggested that minimally a USD 3-4.5 million investment is required for the production and operation of a 0.25-0.5 MT/hr fortified kernel extrusion line[16]. Demand for fortified kernels must exist for private industry to justify an investment in fortified kernel production.

In one hypothetical situation, to fortify the 5.7 MMT of rice considered an opportunity in Africa approximately nine fortified kernel production lines strategically placed in rice export origin countries would be necessary (Table 14). Compared to the global consumption of rice in Asia, fortification of rice in one or two of the identified opportunity countries will not significantly change the economics of rice fortification. For impactful rice fortification at scale and to address the porous borders in this region, regional action will have the greatest likelihood of bringing fortified rice to the tables of 130 million people living in Africa. To create sufficient demand for fortified rice in Africa, a collective strategy for the whole of Africa is necessary – country-by-country action by individual development agencies or voluntary private sector approaches will fail to achieve the scale necessary for rice fortification to succeed as a public health intervention.