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Division of Agriculture
Fayetteville, Arkansas 72704

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The supplementary Microsoft Excel Tables include detailed country-by-country deterministic and stochastic projections.

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International Rice Outlook: International Rice Baseline Projections 2020-2030

Alvaro Durand-Morat and Subir Bairagi[1]

Highlights

- The COVID-19 pandemic created a spike in rice prices in the second quarter of 2020, and since then, prices remain higher than expected given the ample supply available thanks to ample rice stocks and a record 2020 global rice production.
- We project global rice production will surpass global rice consumption for most of the coming decade, with a small deficit developing by the end of the projected period.
- The projected growth in production is exclusively due to productivity gains since the global rice area is projected to decline slightly by 2028–2030. The projected growth in global rice consumption is almost exclusively based on population growth, as the average global per-capita consumption of rice stagnates.
- The international price of long-grain and medium-grain rice is projected to increase in nominal terms but decrease in real terms in the next decade due to ample rice supplies.
- We project that rice demand in Africa will continue to grow at a high pace, thus supporting a fast growth in regional production and imports.
- Global rice trade is projected to increase in nominal and relative (to supply) terms, with Africa being the main driver of the expansion.
- Rice exports will remain highly concentrated among the top-5 exporters. India will remain the largest exporter of rice, while Thailand will consolidate as the second-largest exporter in the coming decade. Myanmar and Cambodia are expected to grow their export market share, while Vietnam, Pakistan, and the U.S. are expected to lose market share in the coming decade.
- On the rice import side, we project that China and Indonesia will lose market share, while Nigeria, Cote d'Ivoire, and Iran will grow their market shares by 2028–2030 relative to the situation in 2017–2019.

Introduction

The coronavirus (COVID-19) pandemic and subsequent lockdowns impacted all economies worldwide and created an economic recession far graver than the Great Recession, contracting the global growth of gross domestic product (GDP) nearly by 4.0% in 2020, compared to -2.0% in 2009 (IHS Markit database). COVID-19 disrupted global and local food supply chains, and resulted in a significant increase in food prices (FAO, 2021). Both global and domestic rice prices increased, driven primarily by temporary export restrictions imposed by several leading rice exporters, such as Vietnam and Myanmar. The market uncertainty also created in panic-buying and hoarding; consequently, the rice demand spiked in similar to that was observed during the 2007-2008 rice crisis. For example, Thai 100% B and Vietnamese 5% long-grain rice prices increased by 30% and 25%, respectively, between March and May 2020 relative to the same period in 2019 (Fig. 1). Although prices in the international market have receded some since then, they remain higher than expected despite the record-high global rice production in 2020.

Despite the disruptions to the supply chain and international trade and the increase in rice prices caused by COVID-19, global rice demand and trade increased in 2020. Many governments around the globe initiated various policy measures to ensure that consumers had access to rice and can afford it (FAO, 2020). For example, India increased rice procurement to 43.7% and 45.1% of the total rice production in its 2019/20 and 2020/21 marketing years (marketing year runs from October to September), respectively, compared to 35.6% on average in the previous three years (2016/17 through 2018/19) (USDA, 2021a). Similarly, in support of the rice sector, China reversed the downward in support observed since 2015 and increased the minimum support prices for long-grain rice for its 2020 and 2021 crop years (USDA, 2021b). In the Western Hemisphere, Brazil removed the Mercosur common external tariff on rice coming from outside the region from September to December 2020. Costa Rica, Panama, and El Salvador imposed import quotas with preferential trade arrangements to facilitate rice importation and curve down the spike in rice prices observed in the domestic market (USDA, 2021c; Urioste Daza, 2020). Similar to the 2007–2008 rice crisis, many countries, especially where rice is the primary staple food, are rethinking how to improve their response to market disruptions to lower the price and market risks and guarantee food security (Sers, 2020).

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As the fight against COVID-19 continues, the degree of market uncertainty from the impact of COVID-19 on the global economy remains unknown. Nonetheless, in April 2021, the International Monetary Fund (IMF) projected that the global economy would expand at a 6% rate in 2021, up from the 5.5% rate projected in January 2021 (WTO, 2021), due to the fast recovery observed among some advanced economies. In a similar tone, the World Trade Organization (WTO) projected that merchandise trade would grow at a rate of 8.0% in 2021 as global and regional value chains are reestablished (WTO, 2021).

The primary goal of this report is to discuss the main findings of our 2020-2030 baseline projections for the global rice market. The projected period includes the ongoing 2020 marketing year since, at the time of the estimation, a large share of the 2020 rice crop in the northern hemisphere and most of the 2020 rice crop in the southern hemisphere was still underway.

Materials and Methods

Arkansas Global Rice Model (AGRM)

The Arkansas Global Rice Model (AGRM) is used to generate a baseline projection of the global rice economy. The AGRM is a partial equilibrium economic model that covers over 70 rice-producing, -consuming, and -trading countries around the world. Each country's rice economy is specified as a system of equations representing rice demand, production, trade, and prices for the two major rice types, namely, long-grain and medium-grain rice. Domestic support and trade policies are embedded in the model equations.

Mathematically, the AGRM can be specified with the following system of linear equations (demand, supply, and price transmission).

$$PC_{c,r,t} = \alpha_0 \times RP_{c,r,t}^{\alpha_1} \times SRP_{c,r,t}^{\alpha_2} \times I_{c,r,t}^{\alpha_3} \quad (1)$$

$$TC_{c,r,t} = PC_{c,r,t} \times POP_{c,t} \quad (2)$$

$$AH_{c,r,t} = \beta_0 \times AH_{c,r,t-1}^{\beta_1} \times PP_{c,r,t}^{\beta_2} \times SPP_{c,r,ct}^{\beta_3} \quad (3)$$

$$Y_{c,r,t} = \gamma_0 \times Fert_{c,r,t}^{\gamma_1} \times Time^{\gamma_2} \quad (4)$$

$$TP_{c,r,t} = \sigma \times Y_{c,r,t} \times AH_{c,r,t} \quad (5)$$

$$ES_{c,r,t} = \delta_0 \times TP_{c,r,t}^{\delta_1} \times RP_{c,r,t-1}^{\delta_2} \quad (6)$$

$$RP_{c,r,t} = \theta_0 \times PP_{c,r,t}^{\theta_1} \times MP_{c,r,t}^{\theta_2} \times (1 \times \lambda) \quad (7)$$

$$PP_{c,r,t} = \varphi_0 \times RP_{c,r,t}^{\varphi_1} \times MP_{c,r,t}^{\varphi_2} \times MSP_{c,r,t}^{\varphi_3} \quad (8)$$

$$MP_{c,r,t} = WP_{r,t} \times ER_{c,r,t} \times (1 + \tau) \quad (9)$$

$$XP_{c,r,t} = WP_{r,t} \times ER_{c,r,t} \times (1 - \omega) \quad (10)$$

$$TS_{c,r,t} = TP_{c,r,t} + M_{c,r,t} + BS_{c,r,t} \quad (11)$$

$$TD_{c,r,t} = TC_{c,r,t} + X_{c,r,t} + ES_{c,r,t} \quad (12)$$

$$\sum_c M_{c,r,t} = \sum_c X_{c,r,t} \quad (13)$$

$$TD_{c,r,t} = TS_{c,r,t} \quad (14)$$

where the subscripts c, r, and t respectively are the country, rice types (long- and medium-grain), and year; PC and TC are respectively the per capita and total rice consumption; POP = population; RP, PP, MP, and XP are the retail, farm, import, and export prices, respectively; SRP and SPP are respectively the retail and farm prices of substitute crops for rice, such as wheat. I = per capita income; AH = harvested rice area; Y = paddy (rough rice) yield; M = imports; X = exports; BS and ES are the beginning and ending stock, respectively, where $BS = ES_{t-1}$; WP = world rice price (Thai 5% broken), which clears the rice markets; ER = exchange rates; TS and TD are the total supply of rice and demand for rice, respectively; σ = paddy to rice conversion ratio; τ and ω are import tariff and export tax, respectively; λ = floor price; MSP = minimum support paddy price; α, β, γ, δ, θ, and φ are the respective demand, supply, and price transmission elasticities, either estimated or taken from the rel-

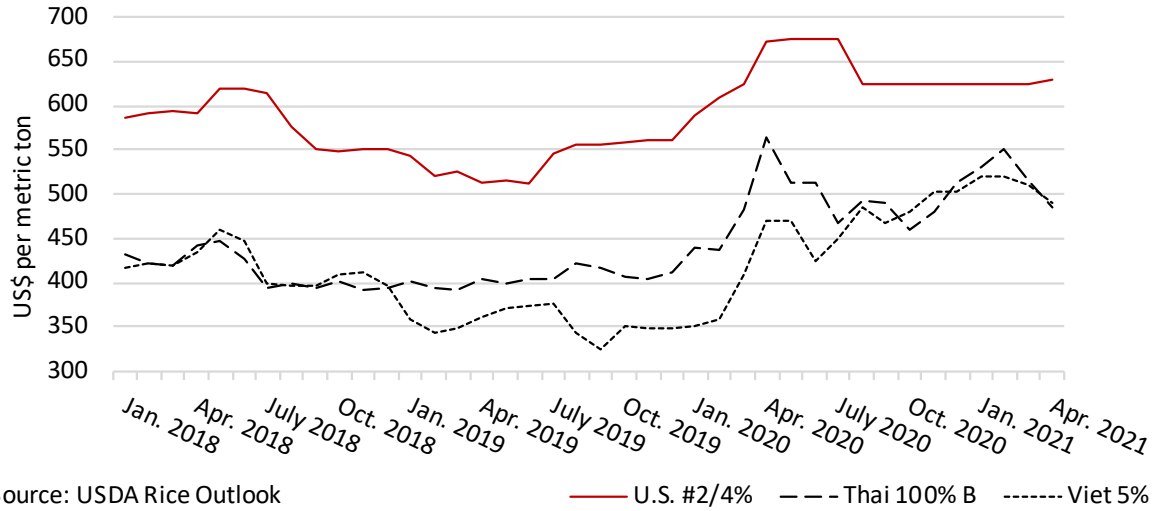


Fig. 1. The monthly average price of long-grain rice from selected exporters.

evant literature. A more detailed specification of the model can be found in Mane and Wailes (2012) and Wailes and Chavez (2011).

Global Macroeconomic Assumptions

The macroeconomic projections used for the calibration of the AGRM model came from IHS Markit, a market data and information services provider (https://ihsmarkit.com). Looking at the top-5 rice-consuming countries, Fig. 2 depicts that COVID-19 had a negative and disproportionate impact on income in 2020. India and Indonesia reported negative economic growth rates but a fast recovery to a more normal year in 2021 for most countries except for Bangladesh. Among the largest rice markets in the Western Hemisphere, Peru and Colombia experienced the largest decreases in economic growth (-11.9% and -7.7%, respectively) but are projected to recover strongly in 2021. Nigeria, the largest rice market in Africa, reported nearly a -3.0% GDP growth rate in 2020 and is projected to resume a small but positive growth rate in 2021 and afterward. In 2030, the global GDP growth rate is estimated at 2.84% annually, slightly higher than in 2019 before COVID-19 disrupted the global economy. Remarkably, developing countries are expected to grow faster than advanced economies, with the highest economic growth are predicted for sub-Saharan Africa (a 3.50% growth in 2030).

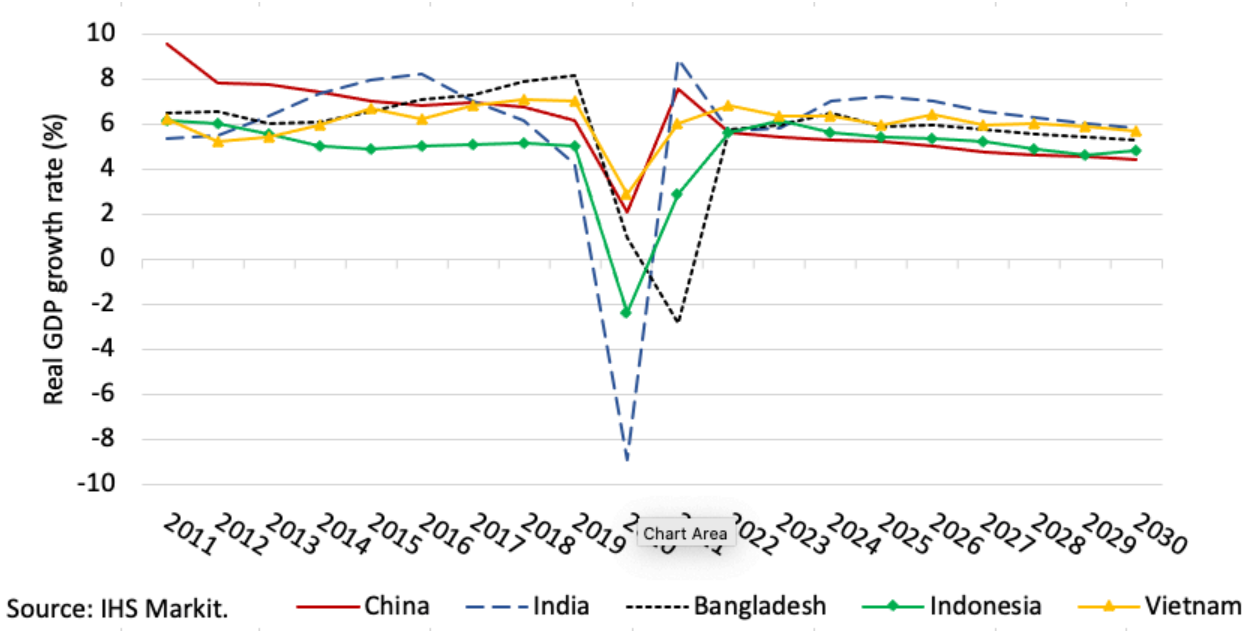


Fig. 2. Economic growth projections for the top-5 rice-consuming countries in the world.

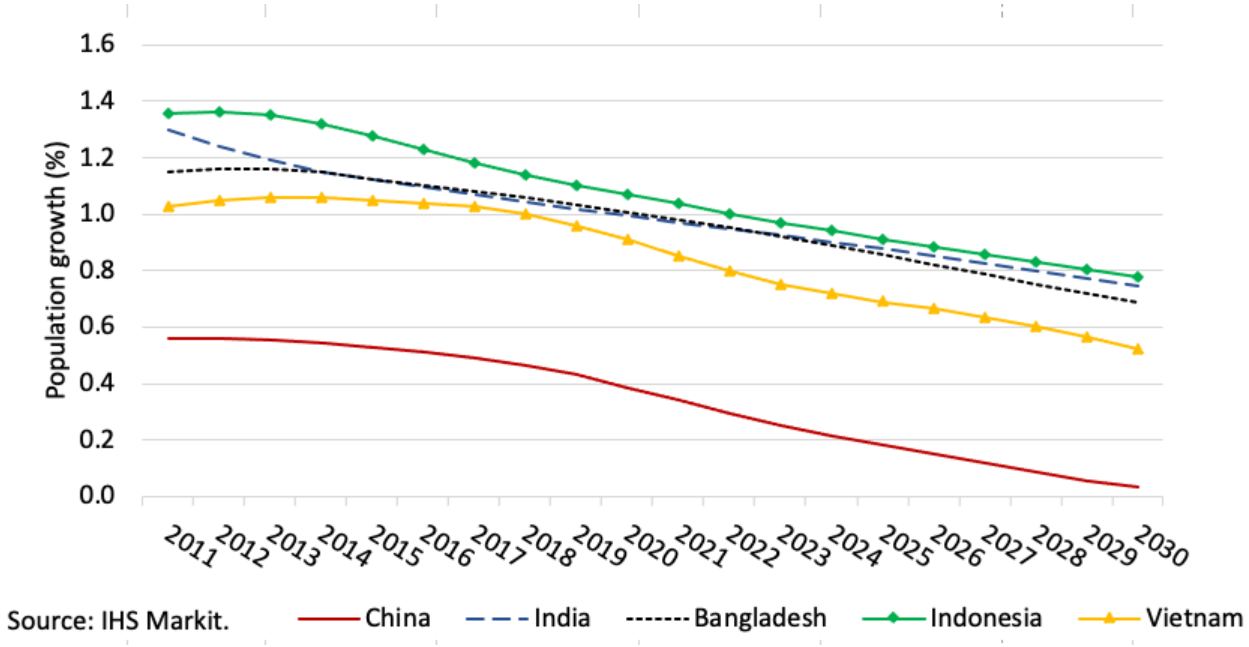


Fig. 3. Population growth projections for the top-5 rice-consuming countries in the world.

While annual population growth rates are projected to decline across the board, developing countries will experience a relatively slighter decline. By 2030 the global population will expand by more than 700 million from its 2020 level, mostly from developing countries. Population growth rates in the top-5 rice-consuming countries are expected to continue decreasing in the coming decade, following the similar trend observed in the last several years (Fig. 3).

Stochastic Simulation Method

In order to capture risk and uncertainties associated in the global rice sector, a stochastic component based on the probabilistic distribution of rice yields is also integrated into the AGRM.

The integration steps involve estimating a fixed-effect model for rice yields and simulating yields with 500 iterations with a multivariate normal distribution. Finally, we randomly select 100 iterated yields for each country and incorporate those into the AGRM baseline model.

The fixed effect regression is specified as:

$$Y_{it} = \vartheta_0 + \vartheta_1 Temp + \vartheta_2 Rain + \vartheta_3 Time + \sum_{\rho=1}^{N-1} \rho Z + e_{it}$$

where Y_{it} is the rice yield for the i^{th} country at period t (the equation was calibrated using 28 years of yield information from 1991 to 2018); *Temp* is the annual temperature in degrees Celsius; *Rain* is the annual precipitation in millimeters; *Time* is a year/trend variable to capture technological advancements over time; Z is a vector of country dummies; ϑ and ρ are the parameters to be estimated; and e_{it} are error terms. The data were gathered from various sources. The historical yields are from the USDA-PSD online database (https://apps.fas.usda.gov/psdonline/app/index.html#/app/advQuery); Temperature and rainfalls are from the Climate Change Knowledge Portal, the World Bank (https://climateknowledgeportal.worldbank.org/download-data); for the U.S. model, statewide rainfall and temperature data were gathered from https://www.ncdc.noaa.gov/cag/.

After estimating equation (15), we use the multivariate normal distribution (MVN) for stochastic simulation to generate 500 yield iterations, out of which 100 iterations were randomly selected to generate the stochastic analysis. The MVN is a generalization of the univariate normal distribution to two or more variables, which has two parameters, a mean vector (μ) and covariance matrix Σ. Suppose that $\Sigma = A'A$, where the diagonal elements are the variances for each variable, and the off-diagonal elements are the covariances between variables. The probability density function (PDF) of the d-dimensional MVN can be specified as:

$$y = f(x, \mu, \Sigma) = \frac{1}{\sqrt{|\Sigma|(2\pi)^d}} \exp\left(-\frac{1}{2}(x-\mu)\Sigma^{-1}(x-\mu)'\right)$$

where x and μ are $1 \times d$ vector and Σ is a $d \times d$ symmetric and positive definite matrix. The simulation steps are: we first generate x such that $x \sim N(0,1)$, and then $y = A'x + \mu$ with $y \sim N(\mu,\Sigma)$. Finally, we use the STATA's "drawnorm" command to general 500 yields for each country in the AGRM. For detailed stochastic simulation, see (Kotz et al., 2000; Ripley, 1987; Rubinstein and Kroese, 2017).

Results and Discussion

Global and Regional Rice Market Outlook: Results from the Deterministic Baseline Analysis

Table 1 presents the current and predicted rice supply and utilization at the global level. At present (2017–2019), worldwide production has outpaced consumption by more than 9.0 million metric tons (mmt), which pushed global rice stocks to more than a quarter of the rice demand (Table 1), the highest level since 2001 (USDA, 2021d). Despite the high level of global rice stocks, rice prices have trended upward since 2015, which partly reflects that most rice stocks are not readily available for trade but rather play an important food security

Table 1. Projected world rice (milled) supply and utilization (units in 1,000 metric tons unless indicated)

Attributes	2017–2019	2028–2030	Nominal Change	% Change (%)
Area Harvested (1000 ha)	161,910	162,466	556	0.34
Yield (kg/ha)	3.06	3.22	0.16	5.23
Production	496,051	523,404	27,353	5.51
Beginning stocks	163,921	187,722	23,801	14.52
Domestic supply	659,972	711,126	51,154	7.75
Consumption	486,653	525,516	38,863	7.99
Ending stocks	173,148	185,422	12,274	7.09
Domestic use	659,801	710,937	51,136	7.75
Total trade	44,677	53,855	9,178	20.54
Stocks-to-use ratio (%)	26.23	26.08	-0.15	-0.57

Notes: Authors' computation, based on the 2021 January baseline analysis of the Arkansas Global Rice Model.

role in some markets. For instance, China and India held 66% and 16% of the global rice stocks in 2017–2019, largely for domestic food security reasons, so they are not readily available for trade. The stocks held by the top-five net rice exporters (excluding India), which may be deemed as readily tradable, amounted to 5% of the global rice stocks in 2017–2019, down from 11% in 2010–2015.

The international price of long-grain (LG) rice, the most popular type of rice produced and traded worldwide (the world's share of long-grain rice, the Thai 100% Grade B, is about two-thirds of the global rice market, while the rest is considered as medium-/short-grain rice in the AGRM) is projected to grow steadily but marginally over the next decade. We project that the nominal price of Thai LG 100% B rice will increase 1.11% annually, reaching $480 per metric ton in 2028-2030, while the price of U.S. LG (#2 FOB Gulf) will increase by 0.56% a year and reach $629 per metric ton by 2028-2030 (Fig. 4). The significant price gap between long-grain rice from Asia and the Western Hemisphere witnessed over the last several years is expected to continue over the next decade. The reason is that importers in the Western Hemisphere continue to source rice mainly from regional suppliers (e.g., U.S. and Mercosur) despite the price discounts for Asian rice (see Key Market Variables to Watch for more). The international nominal price of medium-grain rice, represented by the U.S. medium-grain (MG) rice (#2 FOB California), is also projected to increase steadily but marginally over the next decade, reaching $869 per metric ton by 2028–2030. However, in real terms (adjusting for inflation), the international price of LG (Thai LG 100% B) and MG (U.S. #2 MG California) are projected to decline by 0.98% and 2.02% annually, respectively, over the next decade.

Despite the growth of rice trade relative to supply observed over the last two decades, rice remains thinly traded, with only 6.94% of the rice supply being traded internationally since 2010. Aside from the fact that most rice is consumed where it is produced without crossing borders, the low trade share may also result from the fact that rice remains a highly protected commodity, particularly in many Asian counties where rice is the staple food (Asia dominates the global rice market and accounts for 90% of production, 86% of consumption, 95% of stocks, and 83% of global exports in the 2017–2019 period). We project that the share of rice supply trade internationally will grow slightly to an average of 7.57% by 2028–2030, as demand continues to grow and outpace production in Africa and the Middle East.

At the regional level, Asia is projected to account for the bulk (17.3 mmt out of the 27.4 mmt increase) of the growth in rice production in the next decade. In contrast, Africa will experience the largest relative growth in production with a 27.6% cumulative increase from 2017–2019 to 2028–2030 (Fig. 5). The efforts to improve rice production in Africa after the rice crisis of 2007–2008 resulted in an impressive 49.6% increase in rice production in the last decade (2007–2009 to 2017–2019). We project the growth to slow down relative to that benchmark but continue strong in the coming decade at over 7 times the global production growth average of 5.5%.

The projections on the consumption side are similar to those on the production side. This means that Asia will account for the largest nominal growth in consumption (20.56 mmt out of the 38.86 mmt, or 53% of the increase in consumption), and Africa for the largest relative growth over the next decade, increasing consumption by 41.53% from 37.33 mmt in 2017–2019 ton 52.83 mmt in 2028–2030. In the last decade, rice consumption in Africa grew 59.5% due to rapid growth in per-capita consumption and population. We project that growth to slow down some but will remain strong in the coming decade. Africa's share of global production and consumption is projected to increase over the next decade, primarily at the expense of Asia.

Africa is projected to continue driving the growth in global rice trade to breach the production deficit and serve

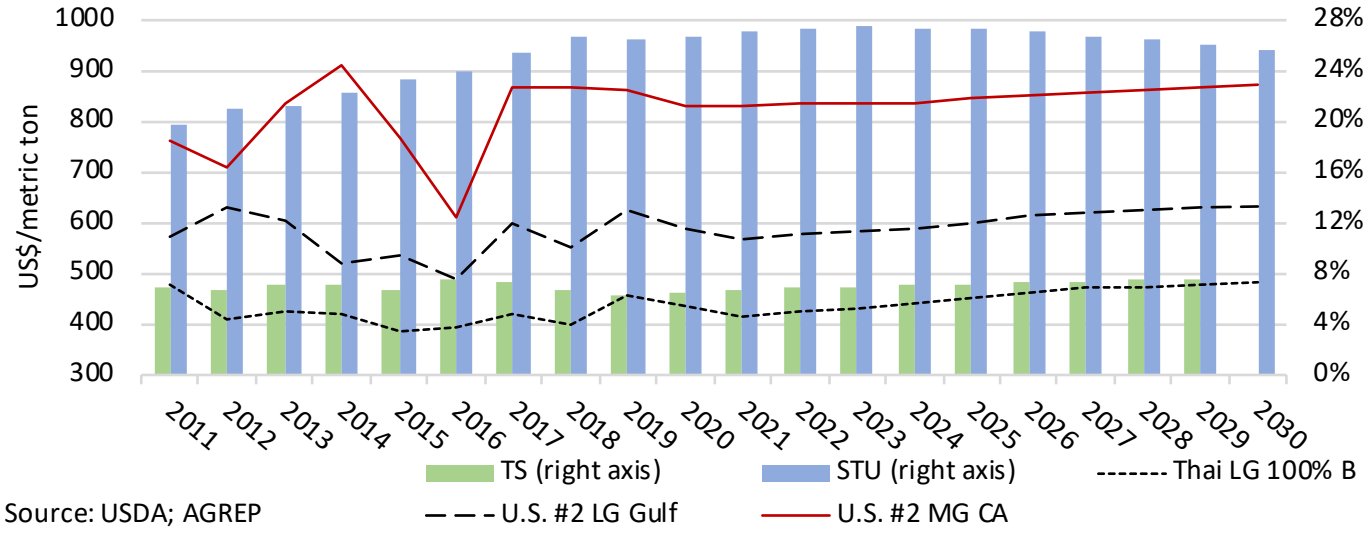


Fig. 4. The international price of long-grain (LG) and medium-grain (MG) rice, trade as a share of supply (TS), and stock-to-use ratio (STU).

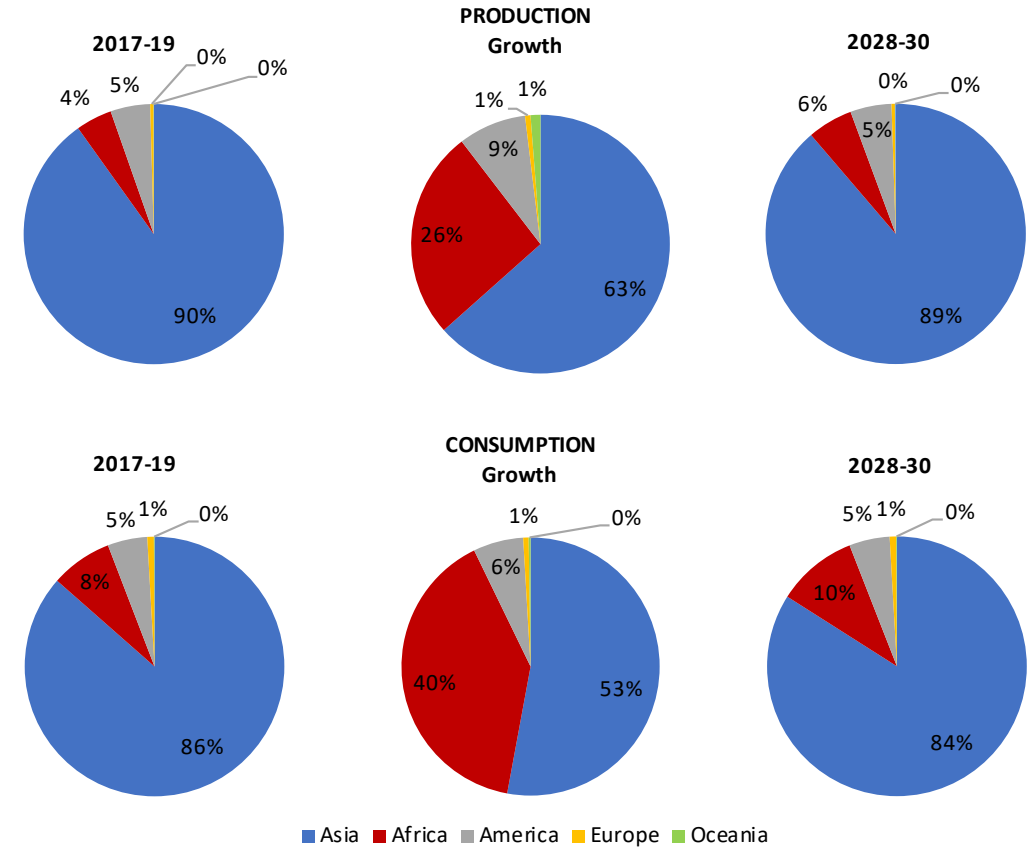


Fig. 5. Projected evolution of regional rice production and consumption shares.

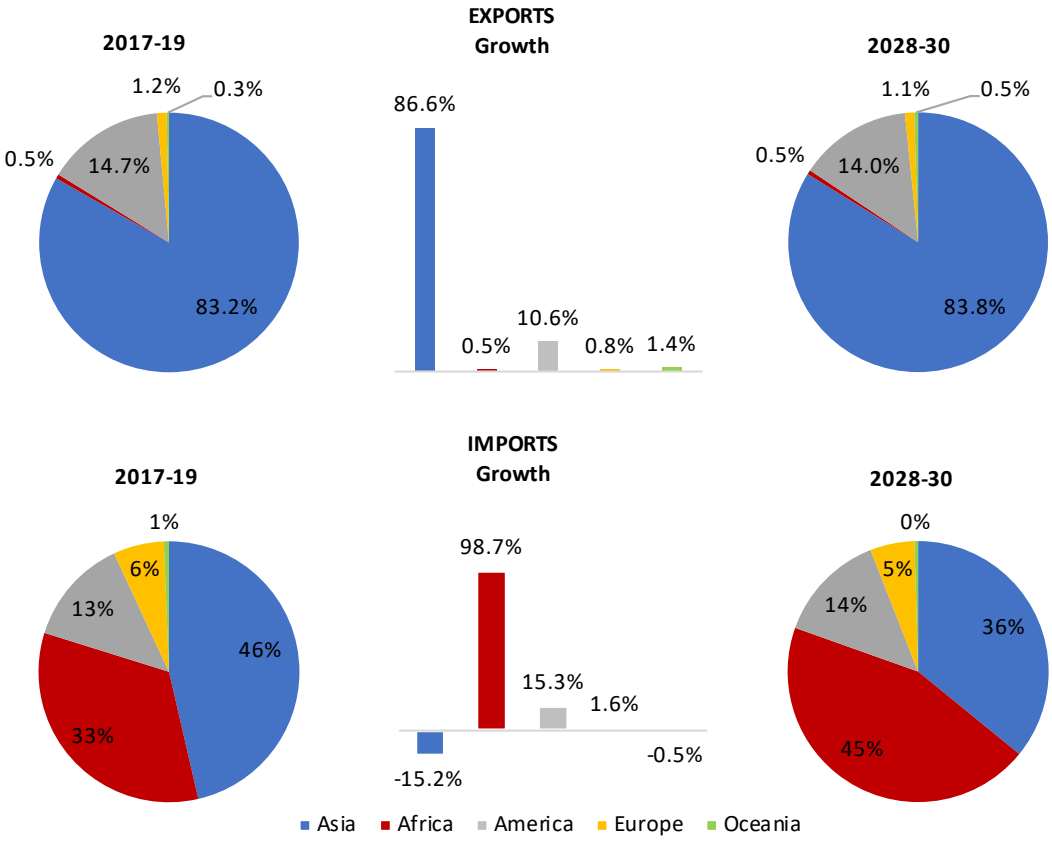


Fig. 6. Projected evolution of regional rice export and import shares.

the fast-growing demand. We project that Africa will account for 98.7% of the growth in imports in the next decade and that it will surpass Asia and become the largest rice importer in 2028–2030. On the export side, Asia accounts for the bulk (86.6%) of the growth in exports, and expand its dominance on the export side (Fig. 6).

Country-Specific Rice Market Outlook: Results from the Deterministic Baseline Analysis

Shifts in Rice Consumption. Several recent articles argue that the food basket in various developing countries will transform in mainly two directions, namely, substitution between food items, such as increasing consumption of animal protein and less of cereals, and within food items, such as increasing consumption of aromatic or brown rice at the expense of regular white rice (Bairagi et al., 2020; Mottaleb et al., 2018). Therefore, it is often argued that the demand for staple food in Asia, such as rice and wheat, will decline, and the demand for non-staple food, such as vegetables, will increase in the future (Pingali, 2015).

Our projections suggest that per-capita consumption in many Asian countries will decline in the coming decade (Fig. 7). However, total consumption will increase purely based on population growth, except in Japan, South Korea, and Thailand, where total consumption is projected to decline. Conversely, total rice consumption is projected to increase strongly across most African countries, based on higher per-capita consumption supported in part by growing income levels in some countries where rice is a normal good (Kruseman et al., 2020; Van Oort et al., 2015), and by a strong population growth across most African nations. For instance, looking at the three largest rice markets in the continent, we project that total consumption in Nigeria will grow almost a third (32.6%) over the next decade, driven mainly by population growth since per-capita consumption increases by only 1.1%. Rice consumption in Egypt is expected to grow 16.7% over the next decade but purely based on population growth since per-capita consumption is projected to decrease by 3.5%. In Madagascar, rice consumption is expected to grow by 36.3% based on both per-capita and population growth. Finally, rice demand is projected to grow in all Latin American countries except in Brazil, the largest rice market outside Asia, where an 11.9% decline in per-capita consumption will more than offset population growth and lead to a 6.2% decline in rice consumption by 2028–2030.

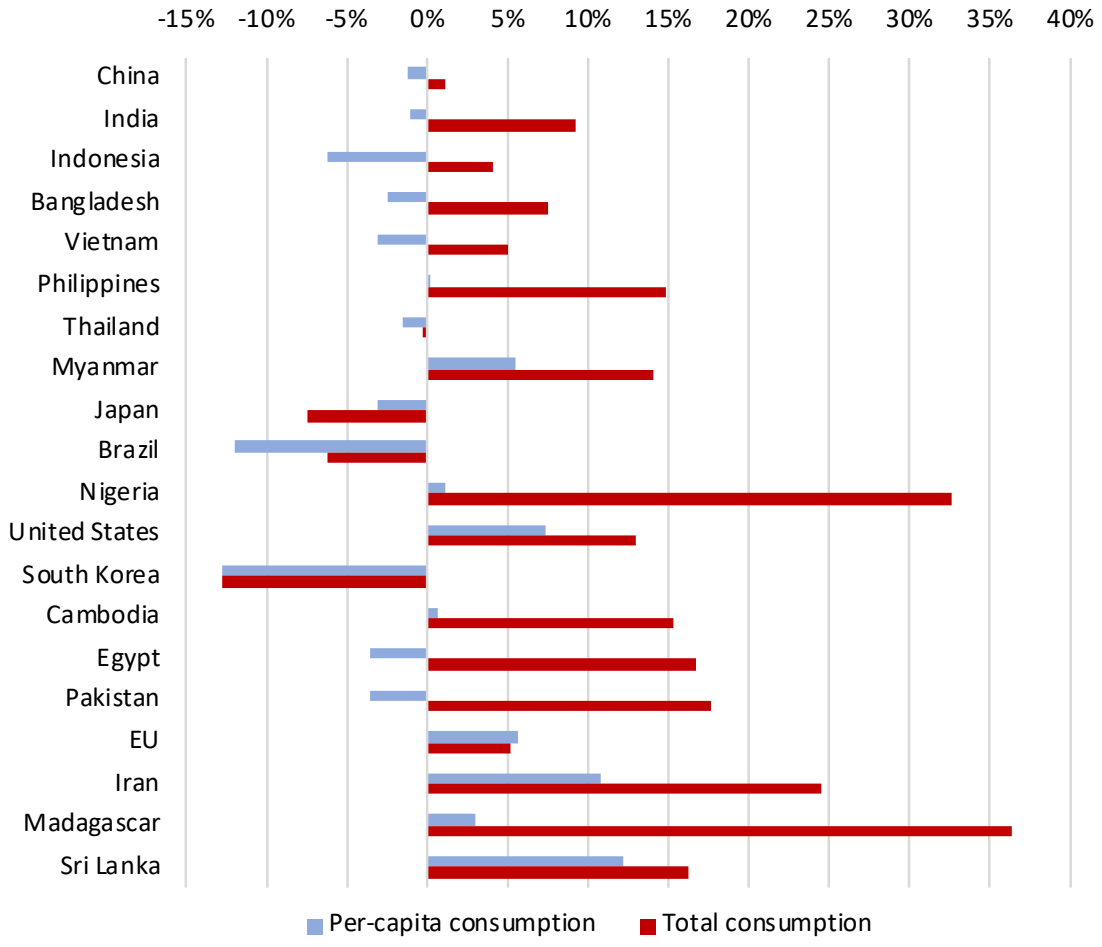


Fig. 7. Projected per capita rice utilization for the world and selected countries.

Shifts in Rice Production. We project that production in China, the largest rice producer in the world, will decrease a cumulative 3.6% over the next decade (Fig. 8). Some of the reasons explaining this decrease in production include the increasing competition with other field crops such as soybeans and corn, and the lower pressure on rice from a food security point of view as demand slows down and the stock level remains high. On the other hand, we project that production in India will continue to grow but at a slower pace than was observed in the last decade, and supported exclusively by yield gains as the area remains unchanged at the 2017–2019 level. The future path of rice yields in India is a key variable that could greatly impact the global rice market in the coming decade (see further discussion in Key Market Variables to Watch). In Indonesia, we project a continuation of the downward trend in area observed since 2015, but yield gains still large enough to sustain a small gain in total production. In Nigeria, Africa's largest rice producer, we project both rice areas and yield to continue growing at rates similar to those observed in the last decade, leading to a 24.5% growth in production by the end of the next decade (2028–2030). In Latin America, we project that the shift in production in Brazil from upland to irrigated rice will ease some as the bulk of the shift already happened, and the area of upland rice stands at an average of 25% of the total area in 2015–2020 relative to 38% in the 1990s. Consequently, the rice area is projected to decrease a cumulative 11.1%, while yields are expected to increase by 7.6%, yielding a net reduction in rice production of 4.2%. In Peru, the second-largest rice producer in Latin America, we project rice area and yields to grow, leading to an 11.0% increase in production by the end of the next decade.

Trends in Rice Trade. Global rice trade grew 46.0% in the last decade (from 30.6 mmt in 2006–2008 to 44.7 mmt in 2017–2019), and we project it will continue to grow but at a slower pace and reach 53.9 mmt by 2028–2030, that is, a cumulative 20.5% growth from its 2017–2019 level. Rice trade is highly concentrated on the export side, with five countries (India, Thailand, Vietnam, Pakistan, and the U.S.) accounting for 75% of the total volume of exports in 2017–2019, down from a share of 80% in 2006–2008. We project the same 5 countries will continue to dominate on the export side, but their cumulative share will decline slightly to 73.7% by the end of the next decade (2028–2030). Myanmar's exports are projected to grow and get almost at part with U.S. exports. Arguably the most prominent development on the export side in the last decade has been the rise of India as a steady and leading exporter of rice, growing from a 14% export share in 2006–2008 to slightly over

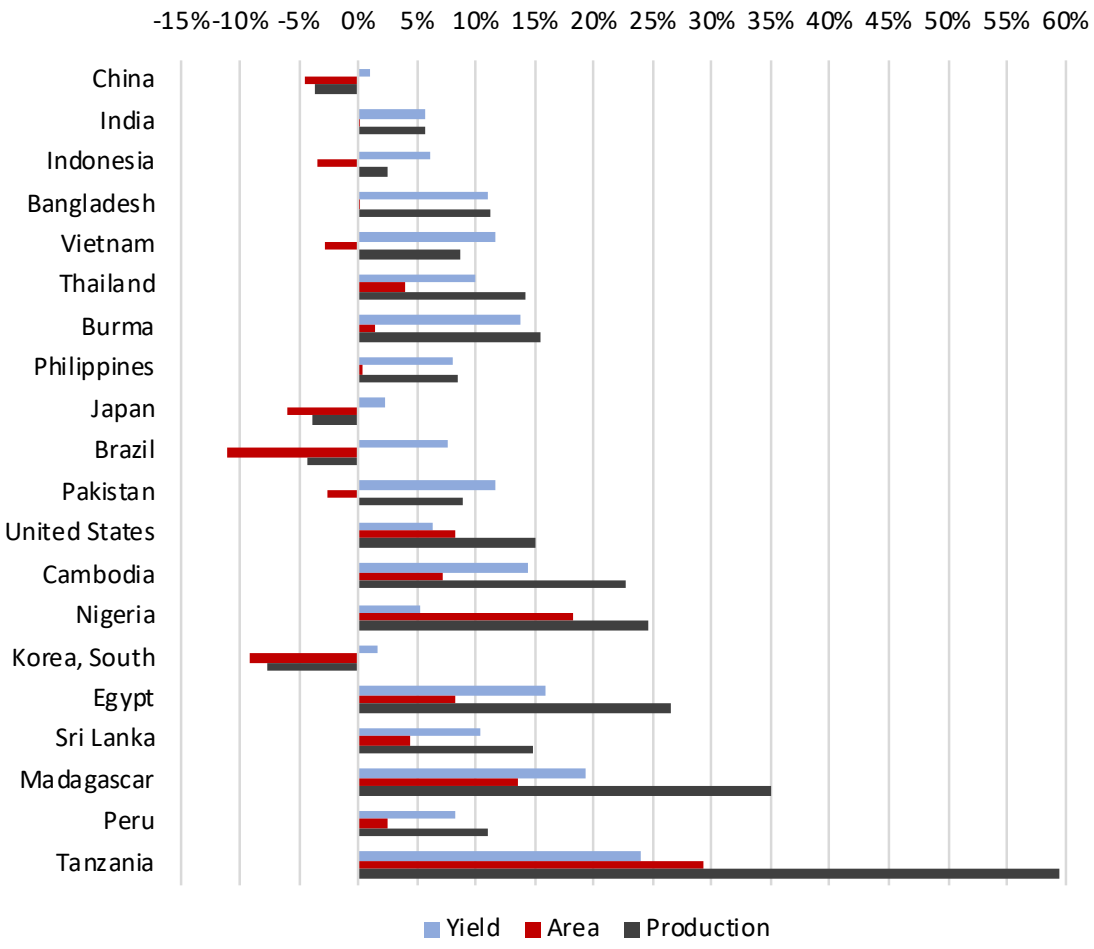


Fig. 8. Projected cumulative changes in rice production among the 20 largest rice markets in 2028–2030 compared to 2017–2019.

a quarter in 2017–2019 (Fig. 9). We project that India will remain the largest exporter of rice in the coming decade, accounting for a quarter of global rice exports in 2028–2030. Thailand has recently lost market share due to a series of weather-related production shocks that have tightened the market and undermined its competitiveness. We project that Thailand will regain its presence and consolidate as the second-largest exporter after India. While Myanmar and Cambodia are expected to grow their export market share in the coming decade, Vietnam, Pakistan, and the U.S. are expected to increase their exports in nominal terms but lose market share. Finally, China has been in and out of the export market in the last decade, but we project it will become a more consistent exporter, holding a 5% market share by 2028–2030.

The rice market is much less concentrated on the import side. Looking at the rice import shares of top rice importers, we project a slight increase in the concentration of imports, but still the top 8 rice importers account for less than 40% of the total volume of rice traded globally by the end of the next decade (2028–2030). There is little expected variation in the market shares held by the top importers; most notably, we project that China and Indonesia will lose, while Nigeria, Cote d'Ivoire, and Iran will grow their market shares relative to the situation in 2017–2019 (Fig. 10).

U.S. Rice Market. The results presented in this section differ slightly from those presented by FAPRI in its 2021 U.S. Agricultural Market Outlook, which are based on a baseline generated in January 2021. The reason for the slight differences is that we updated the AGRM model since then to reflect more current market conditions. Regardless of the slight differences, the main findings from the projection remain unchanged.

Table 2 presents the U.S. rice supply and utilization by types (namely, LG and MG; MG includes both medium- and short-grain rice). We project that the production of LG rice will increase significantly in the coming decade relative to the 2017–2019 benchmark period (LG ice production in 2017/2018 and 2019/2020, two of the years included in the benchmark 2017–2019 period, were hampered by weather-related events

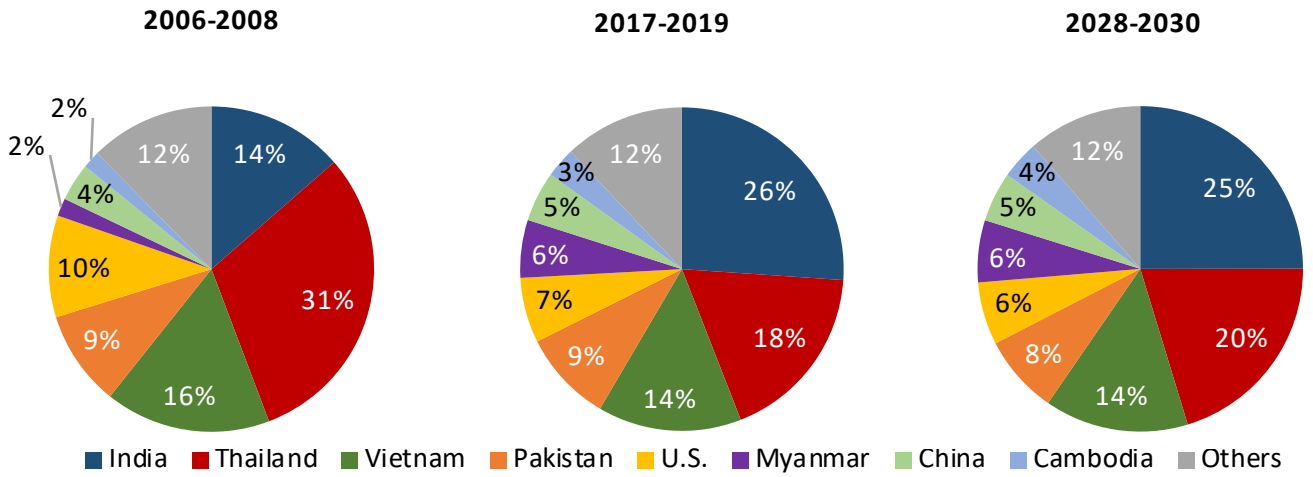


Fig. 9. Export shares by the top rice exporters.

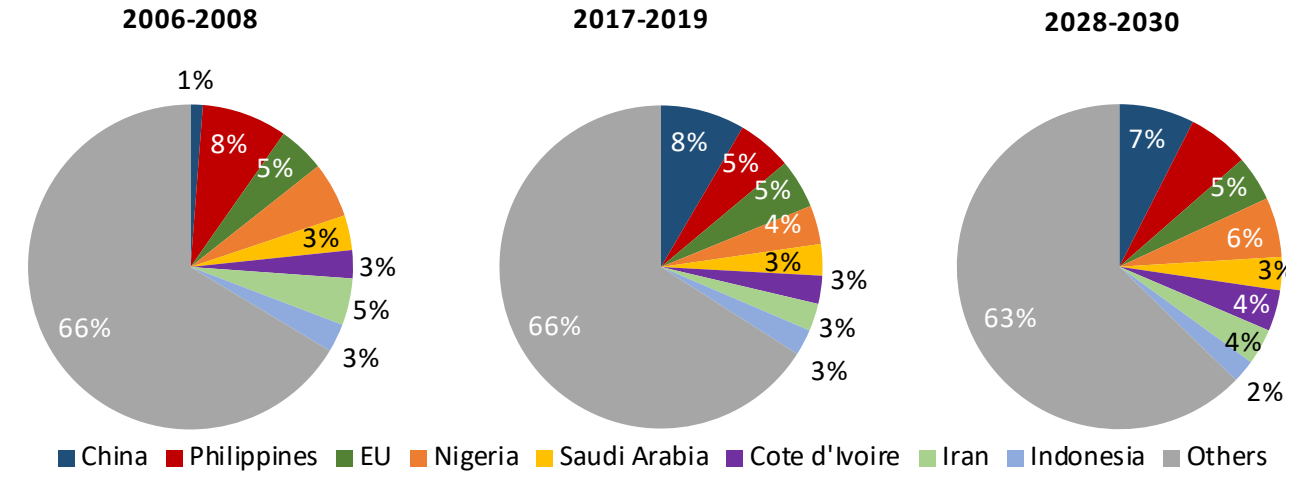


Fig. 10. Import shares by the top rice importers.

that resulted in small LG crops), but remain on-trend relative to the behavior observed since 2010. To put these numbers in perspective, the volume of production projected in 2028–2030 is similar to the 2018/2019 LG crop. The projected increase in LG production is supported by increases in both area and yields. Exports of LG rice will remain relatively flat in the short term, but pick up their pace by the end of the next decade, reaching levels similar to those observed in 2010/2011 and more recently in 2016/2017. The U.S. will continue trading LG rice primarily across markets in the Western hemisphere, in many of which U.S. rice has preferential treatment under regional trade agreements. In recent years U.S. LG rice has not been competitive vis-à-vis LG Asian rice in other markets of interest, such as the Middle East and Africa. We project that domestic use (consumption plus ending stocks) will grow at a slower pace in the coming decade relative to that observed in the past decade. The growth is supported by an increase in consumption due to both population growth and per-capita consumption, and an increase in ending stocks, which will reach a level seen recently in 2016/2017 and 2018/2019. On the import side, it is important to notice that we include imports of aromatic (jasmine and basmati) rice as LG rice. With that in mind, we project imports will continue to grow strongly but at a slower pace than that observed in the last decade, following the trend of domestic use. Looking at the MG segment of the market, we project that the production of MG rice will increase slightly in the coming decade relative to the 2017–2019 benchmark period (MG rice production in 2017/2018 was the lowest since the 2006/2007 crop), and remain on-trend relative to the behavior observed since 2010. To put these numbers in perspective, the volume of production that is projected in 2028–2030 is similar to the recent 2019/2020 MG crop. The projected increase in MG production is supported exclusively by increases in yields since the planted area is projected to decrease in the coming decade. Exports of MG rice will remain relatively flat in the projected period at a level below that observed in 2017–2019. The U.S. trades MG rice primarily along the lines of negotiated, and mostly fixed, WTO quotas (e.g., California MG rice into Japan, South Korea, Taiwan), and competes in the open market (e.g., Turkey, Egypt) primarily with southern MG, which has encountered fierce competition from China in recent years (see China's Rice Stocks for more). We project that domestic use (consumption plus ending stocks) will grow at a similar pace in the coming decade relative to that observed in the past decade. The growth is supported by an increase in ending stocks since consumption is projected to decline slightly in the coming decade. While the levels of ending stocks projected by 2028–2030 are well within the levels observed in the last decade, it remains to be seen if they are sustainable given the projected decrease in domestic consumption. Imports of MG rice, although small relative to total supply, have increased sharply since 2016/2017, and are expected to continue growing but at a significantly lower rate in the coming decade.

Figure 11 illustrates the dynamics of rice farm prices. The price of both LG and MG rice is projected to increase steadily but slightly over the next decade. California MG rice is projected to maintain the price premium over southern MG and long-grain rice. Similar to their behavior in the last several seasons, the premium for southern MG over long-grain rice will remain small.

Key Results from the Stochastic Analysis

The stochastic simulation generates a probability distribution for each endogenous variable in the model. For the sake of brevity, we discuss here the stochastic projections for few selected variables. All other stochastic results are available from the authors upon request.

Table 2. United States rice supply and utilization by types.

	All Rice			Long-grain			Medium- and short-grain		
Variables	2017–2019	2028–2030	Annual growth (%)	2017–2019	2028–2030	Annual growth (%)	2017–2019	2028–2030	Annual growth (%)
Planted area (million ac)	2.58	2.80	0.82	1.88	2.11	1.16	0.7	0.69	-0.14
Yield (lb/ac)	7585	8036	0.58	7403	7876	0.62	8074	8493	0.51
Production (million cwt)	195.7	225.0	1.40	139.0	166.0	1.79	56.7	59.0	0.40
Domestic use (million cwt)	141.2	159.5	1.23	104.5	121.4	1.51	36.7	38.1	0.38
Exports (million cwt)	91.6	105.6	1.43	64.7	77.3	1.80	26.9	28.3	0.51
Imports (million cwt)	31.3	40.9	2.71	25.5	33.4	2.74	5.8	7.5	2.60
Ending stocks (million cwt)	33.1	43.7	2.82	23.6	31.5	2.93	9.5	12.2	2.53
Farm price ($/cwt)	14.09	14.74	0.46	11.43	12.91	1.23	20.6	19.9	-0.35

Notes: 1 cwt (hundred weight) = 100 lb = 0.0204 metric tons. Annual growth is calculated over 2017–2019 to 2028–2030.

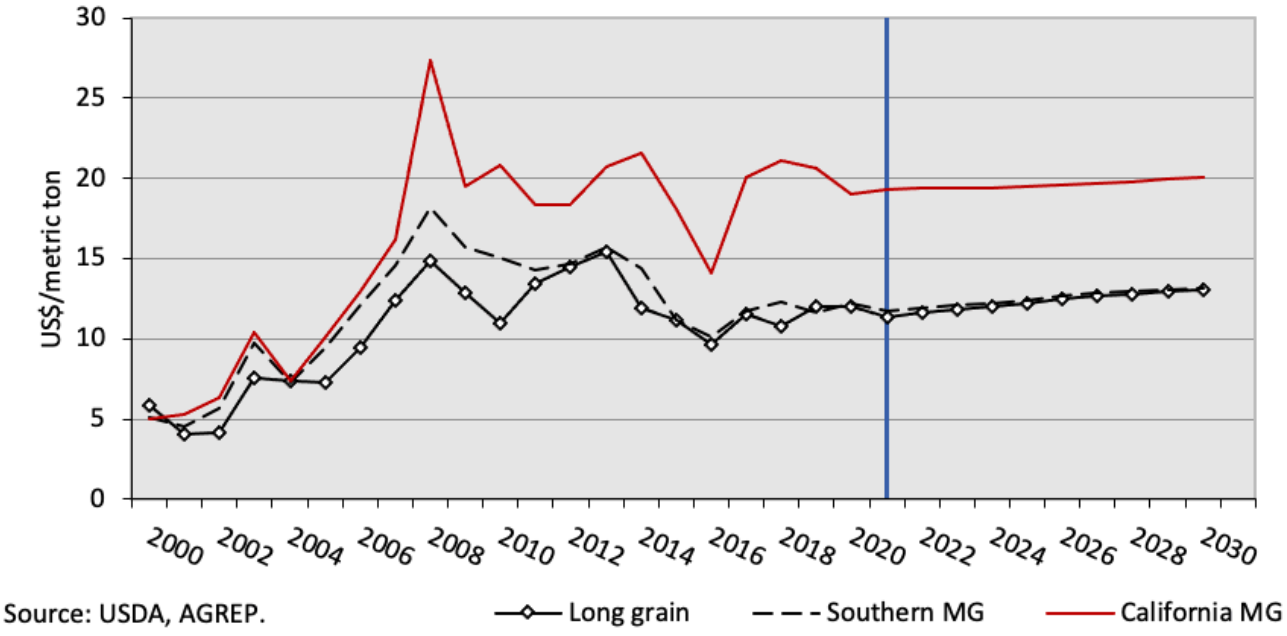
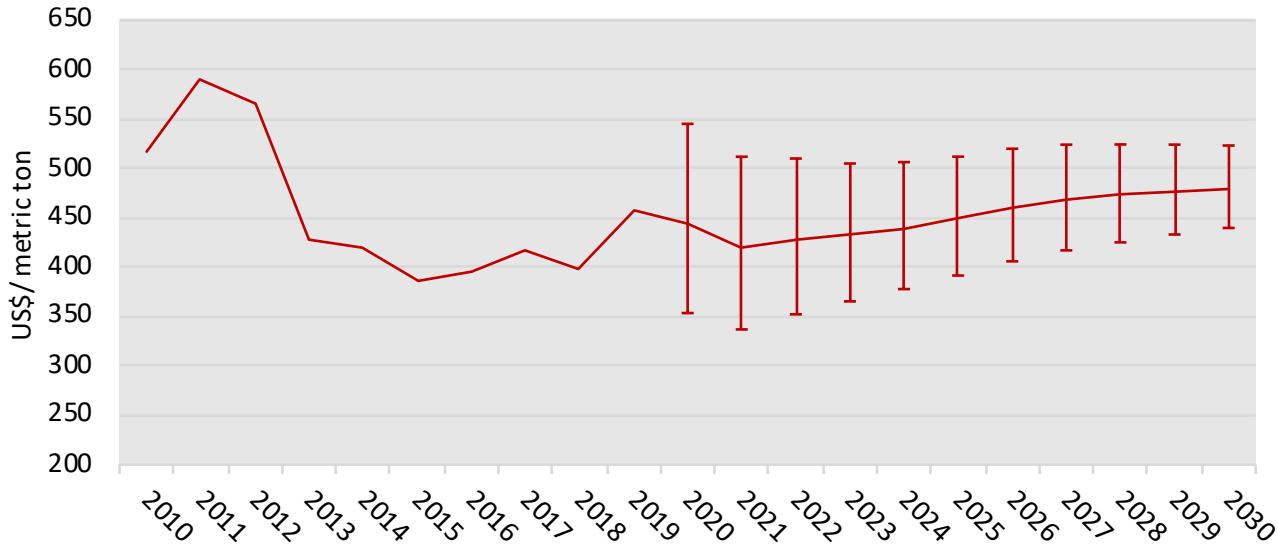


Fig. 11. Rice farm prices in the United States: 2000–2030.



Source: USDA; AGREP.

Fig. 12. Stochastic projection of the export price of Thai LG 100% B rice in the next decade.

Figure 12 shows the stochastic projected behavior of the export price of Thailand LG 100% B rice, the reference price that clears the international LG market. The vertical lines mark the range of variability between the 10th and 90th percentile. We project that the export price of Thai LG 100% B, and by extension the international price of long-grain rice, will be highly volatile in the short term, with an 80% confidence that the price will be between US$337 and US$512 in 2021, and a coefficient of variation (CV) of 0.170 or 17.0%. The coefficient of variation (CV) measures the dispersion of the data around the mean, and it is estimated as the ratio of the standard deviation to the mean. The CV is a useful statistic for comparing the degree of variation from one data series to another, even if the means are drastically different from one another. We estimate that the volatility will recede some by the end of the projected period, with an 80% confidence that the price for Thai LG 100% B will be between US$439 and US$523/metric ton by 2030, and a CV of 7.4%.

Looking at the stochastic projection of global production and consumption (Fig. 13), we see that their volatility is low and decreases over the projected period to reach a CV of under 1% by 2030. This low volatility is in part due to the aggregate nature of the variables; production and consumption at the regional and country level (not shown) show a much more uncertain behavior. On the other hand, despite its aggregate nature, the uncertainty around ending stocks increases, reaching a CV of 12.9% by 2030.

Finally, we project with 80% confidence that global rice trade in 2021 will be between 42.4 and 50.3 million metric tons (CV of 6.2%), and the uncertainty will decrease slightly over the next decade reaching a CV of 4.3% by 2030 (Fig. 14).

Key Market Variables to Watch

China's Rice Stocks

China currently has a record level of stocks, estimated at an average of 113.5 mmt in 2017–2019, compared to the previous highest level of 97.4 mmt in 1999. Relative to the demand, the current stock level amounts to nearly 80.0% of China's annual rice consumption, compared to 73.0% back in 1999. The stock buildup that started in the late 2000s is supported by a sustained level of production facilitated by favorable domestic policies, a steady volume of imports under the auspice of the WTO, and a slowdown in total rice consumption. One of the key questions looming over the rice market is what China will do with its rice stocks, more precisely whether stocks will continue building up (stats from the last few years suggest a slowdown in stock buildup), or will be disposed and, if so, how. The scarce evidence from the last few marketing years suggests that China relies on both exports and increased domestic use to curve down stocks. Rice auctions for feed have been ramping up (the USDA, 2021e, reports the sale of 9 mmt of old stock rice since September 2020), and are seen as the least disruptive way to address the situation. However, China has also been ramping up rice exports, primarily of long-grain rice destined to Africa, and of Japonica (medium- and short-grain) rice at highly competitive prices to markets in northern Africa (primarily in Egypt), Turkey, and Puerto Rico. To illustrate, China accounted for 52% and 64% of the imported rice by Turkey and Egypt in 2019, respectively, relative to negligible amounts reported up to 2016 (UN Comtrade Database https://comtrade.un.org/). Because of the relatively small size of the *Japonica* rice market and the large volume of stocks of that type held by China (according

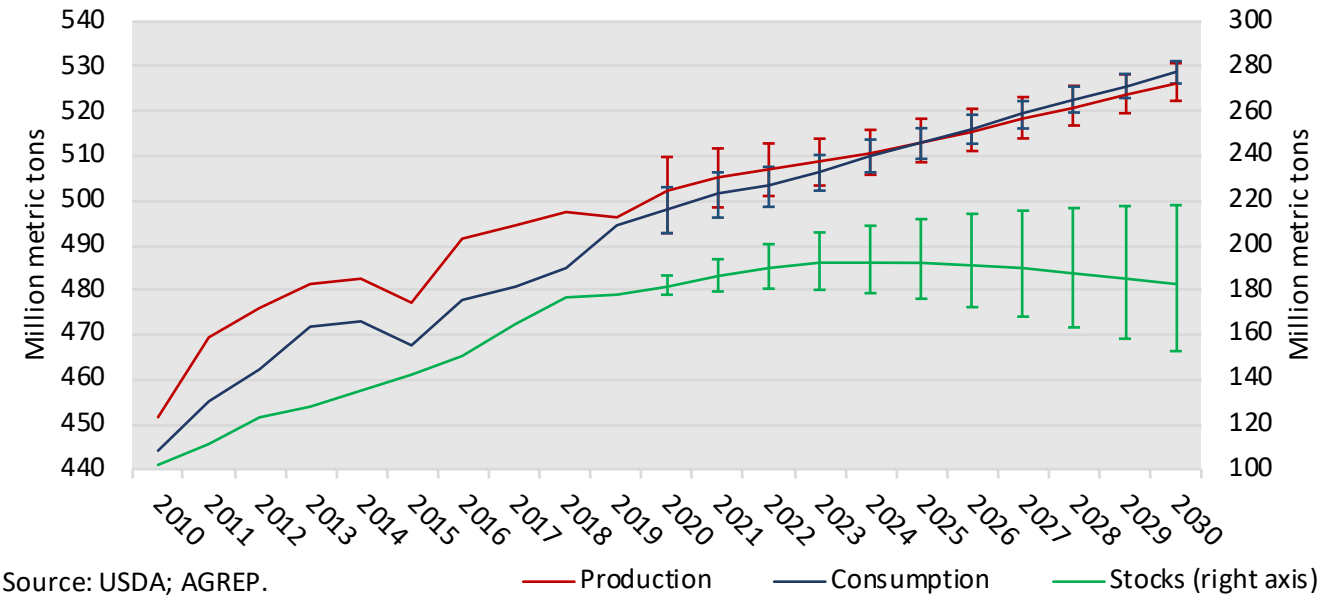
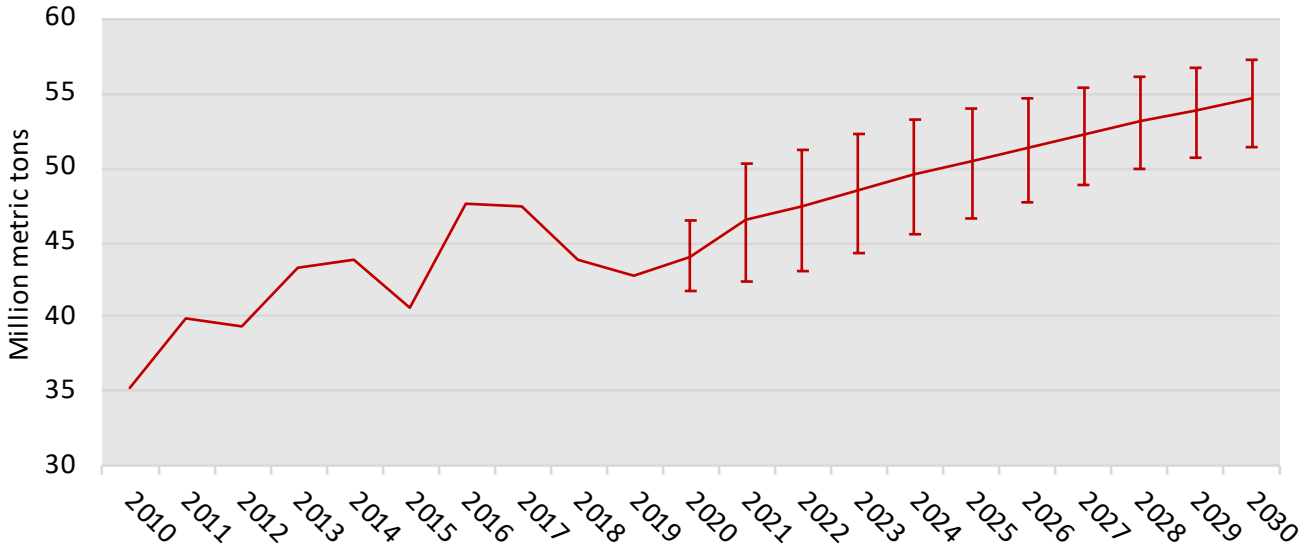


Fig. 13. Stochastic projection of global rice production, consumption, and ending stocks in the next decade.

to USDA, 2021, 85% of the existing rice stocks are *japonica* rice), the management of stocks is crucial for that segment of the rice market. Our assumption for the next decade (Fig. 15) is that China will strive to maintain rice stocks at the 2017–2019 level, but we can infer how a change in this assumption could have enormous implications for the global rice market.

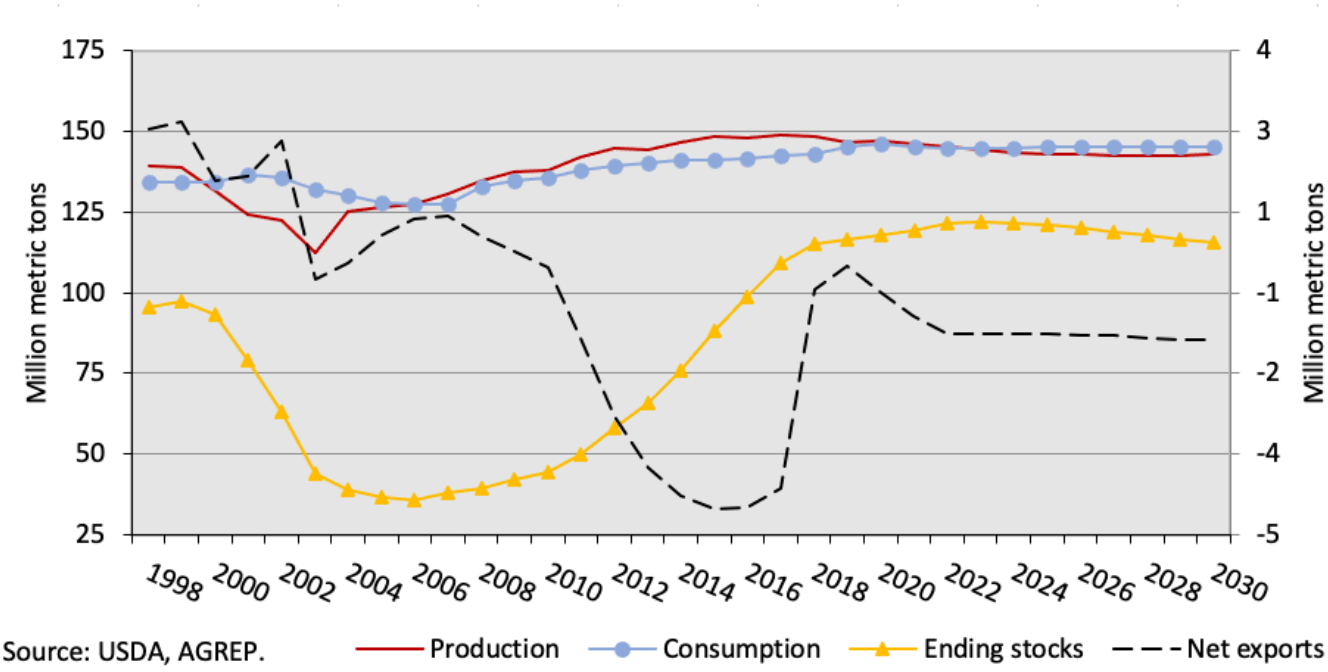
India's Rice Yields and Production

India's production record in the last 20 years has been impressive, expanding from 89.7 mmt in 1999 to 118.4 in 2019 (approximately 28.7 mmt of more rice was produced). This trend in production translates to an average growth rate of 1.4% a year, almost twice the global average rate of 0.8% achieved in the last two decades. The production gain came exclusively from yield improvements since the actual area harvested decreased by 3.1% since 1999. Average rice yields grew 1.6% a year from 1.99 metric tons per hectare in 1999 to 2.71 metric tons per hectare in 2019. Such productivity growth is mainly due to the development and dissemination of improved production technologies such as high-yielding and flood/drought-tolerant rice varieties, the development of irrigation infrastructure, and the use of chemical fertilizer



Source: USDA; AGREP.

Fig. 14. Stochastic projection of global rice trade in the next decade.



Source: USDA, AGREP.

Fig. 15. China rice supply and utilization (exports shown on right axis).

(Kavi, 2021; Mahajan et al., 2017). Our projections indicate that rice yields in India will continue to grow but at a much slower pace in the coming decade (Fig. 16). We hypothesize that the yield growths of many of the established rice varieties have nearly been exhausted, and productivity gains from increasing input use will increase but at a decreasing rate. We project that the rice yield will grow 0.4% a year, and the area will decrease by 0.1% annually, leading to a 0.2% average annual increase in production over the next decade.

Even with this projected slowdown in production growth, we expect India to remain the largest rice exporter worldwide. If India manages to keep the growth observed in the last two decades (e.g., via increasing adoption of hybrid rice and irrigation), then we can expect that the international rice market will find an equilibrium at much lower prices than what our projections suggest, which will have strong implications for the patterns of production and consumption worldwide.

Price Gaps Between Asian and Western Hemisphere Rice

Historically, long-grain rice exports from the Western Hemisphere (e.g., the U.S. and Mercosur) have been priced higher than most of those originating from Asia. To illustrate, Fig. 17 shows that the nominal and relative (to the price of Thai 100%B rice) premium has varied widely but in general trended downward from 1982 until the rice market crisis of 2007/2008, when the international market price of Thai 100%B rice tripled from $335 per ton to over $1000 per ton (Dawe and Slayton, 2010). The price premium remained close to zero and even reversed in 2012 when Thailand launched its ambitious rice-pledging program, resulting in higher Thai rice prices and lower export competitiveness. Nonetheless, the price premium increased sharply in 2013 and has been 34% on average since 2014. One of the reasons supporting the price gap between Western Hemisphere and Asian rice is the level of trade integration in the former, and the fact that most rice trade remains regional and benefits from a preferential trade policy treatment. Another reason for the price gap that is often cited anecdotally by rice traders (although not well reference scientifically) is the difference in quality that results, among other things, from having a more modern milling industry in the Western Hemisphere. We argue that some market and policy developments could reduce the price premium in the coming decade. For instance, trade integration between Western Hemisphere and Asian countries (e.g., Trans-Pacific Partnership) may create a more leveled playing field and improve the competitiveness of Asian rice in key core markets in the Americas. Additionally, upgrades in the rice supply chains across Asia are ongoing and resulting in high-quality rice that can compete very well in the most demanding markets. These above developments may reduce the price gaps, which could be detrimental to the rice industry in the Western Hemisphere.

Summary and Conclusion

Rice is a crucial global staple and the cornerstone of food security programs around the world, and remains one of the most regulated global staple foods. Hence, understanding the future behavior of the global rice market is of the utmost importance, as it can help policymakers, industry leaders, and agents throughout the rice supply chain to develop strategies that will help cope with the projected market changes. This report outlines the main findings from the 2020–2030 baseline projections of the global rice market outlook developed by the Arkansas Global Rice Economics Program.

Based on the results from model simulations, over the next decade, the overall rice story is that global production and consumption will continue to grow strong, with a marginal deficit developing by the end of the projected period. Global

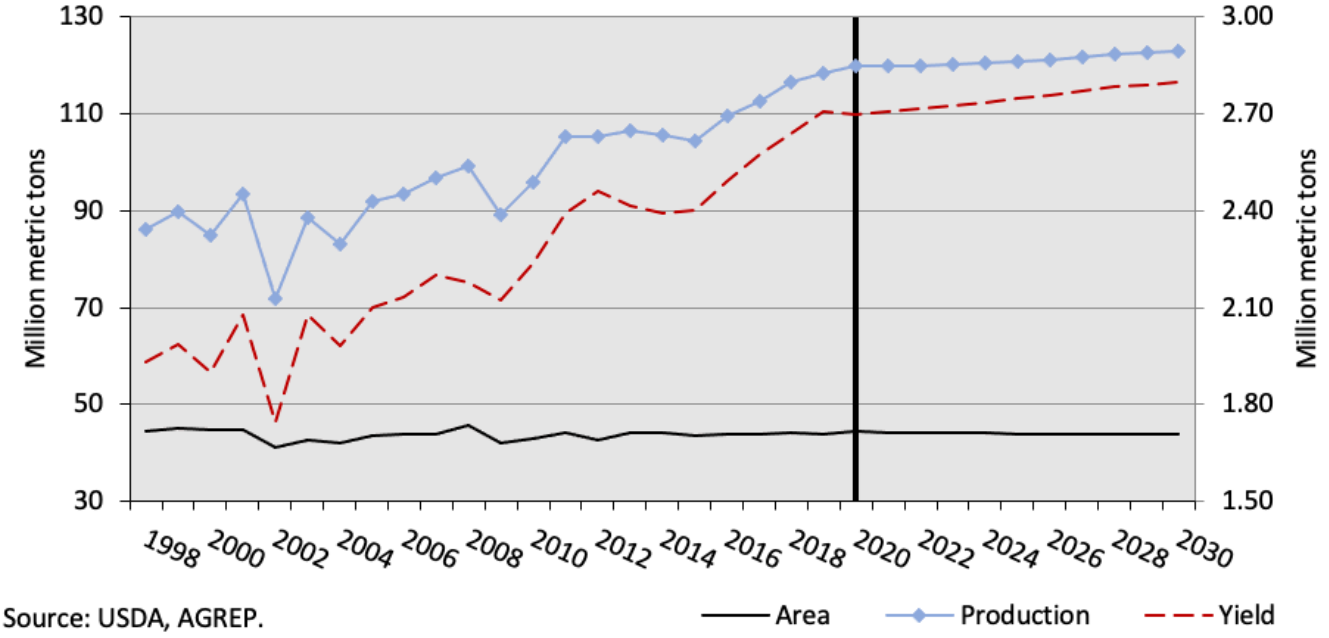


Fig. 16. India's historical and projected rice area, yield, and volume of production (exports shown on right axis).

rice production is projected to grow at a higher pace than what we projected last year, based almost exclusively on yield gains as the total rice area is projected to remain stable.

At the regional level, most of the nominal growth in production and consumption is expected to happen in Asia, but Africa is projected to become more relevant from a production and consumption point of view in the next decade. Africa is projected to account for the vast majority of the growth in imports in the next decade, surpassing Asia as the largest rice importer in 2028–2030.

At the country level, rice production is projected to decrease in China, Japan, South Korea, and Brazil, and grow the most in Tanzania, Madagascar, Egypt, and Nigeria, relative to the production level observed in 2017–2019. On the other hand, total rice consumption is projected to decline in Japan, South Korea, and Brazil, and increase strongly in the African nations of Madagascar and Nigeria, as well as in Iran.

These differential changes in production and consumption across countries will push global rice trade to new records. India will continue to be a leader on the export side, while Thailand is projected to secure its place as the second-largest exporter of rice. Rice exports will continue to be highly concentrated among the top-5 largest exporters.

The global rice market is subject to many factors that could alter its projected path. Among the key factors to keep an eye in the future because of their potential impact on the global rice market, we highlight the following three: (1) China's rice stock management, (2) India's yield and overall production trend, and (3) the price gap between Asian and American LG rice.

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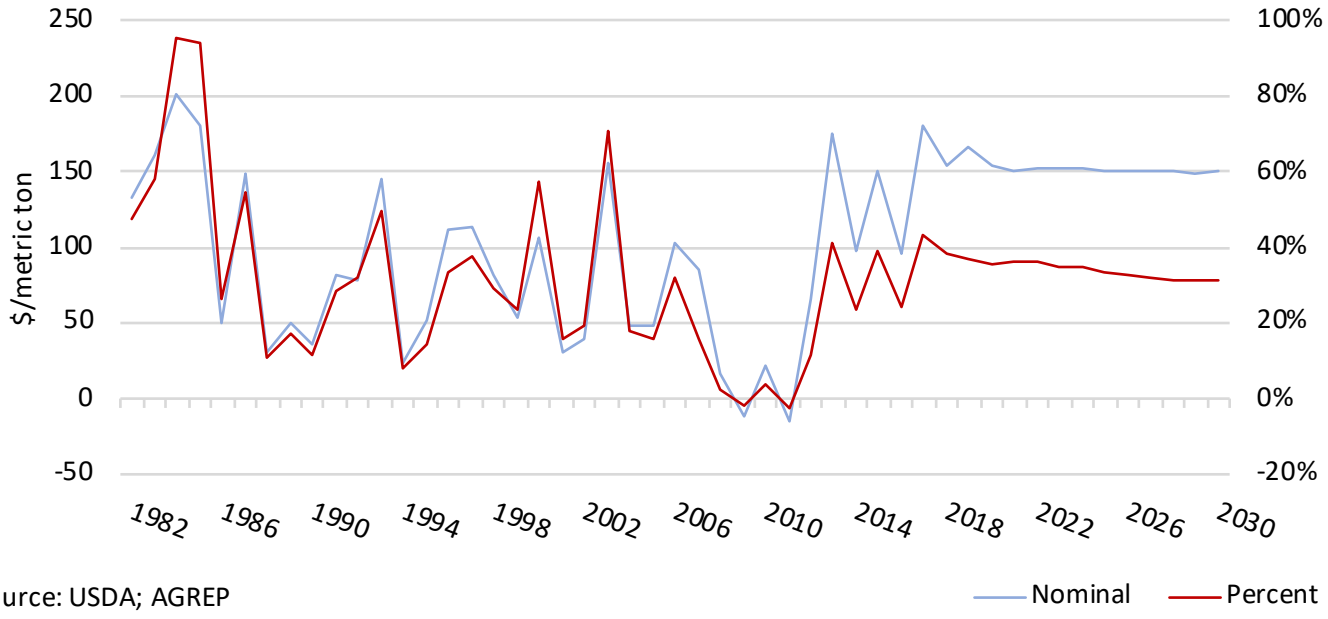

Fig. 17. The price gap between Thai 100%B and U.S. #2 long-grain rice (percent = price gap/price of Thai 100%B).

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APPENDIX

Table A1. Country-wise changes in rice production and consumption around the world.

Country	Production			Consumption		
	2017–2019	2028–2030	Change	2017–2019	2028–2030	Change
	1,000 metric tons					
East Asia & Pacific						
Australia	181	518	337	345	420	75
Brunei Darussalam	1	1	-	36	59	23
Cambodia	5,679	6,965	1,287	4,283	4,937	654
People's Republic of China	148,031	142,644	(5,387)	143,553	145,103	1,550
China-Hong Kong				324	396	72
Indonesia	35,067	35,970	903	36,267	37,726	1,459
Japan	7,685	7,393	(292)	8,450	7,815	(635)
Lao PDR	1,877	2,520	643	1,983	2,104	120
Malaysia	1,823	2,111	287	2,783	2,935	152
Myanmar (Burma)	13,033	15,040	2,006	10,267	11,715	1,448
Philippines	11,965	12,980	1,015	13,883	15,951	2,067
Singapore				319	320	1
South Korea	3,861	3,564	(298)	4,473	3,906	(567)
Taiwan	1,282	1,048	(234)	1,173	1,130	(44)
Thailand	19,524	22,305	2,781	11,600	11,572	(28)
Vietnam	27,367	29,714	2,347	21,317	22,401	1,084
South Asia						
Bangladesh	34,470	38,326	3,856	35,367	38,031	2,664
India	115,889	122,570	6,681	101,189	110,460	9,271
Pakistan	7,333	7,978	645	3,333	3,923	590
Sri Lanka	2,836	3,254	418	2,917	3,390	473
Middle East & North Africa						
Egypt	3,800	4,804	1,004	4,233	4,940	706
Iran	2,000	2,129	130	3,233	4,024	791
Iraq	162	343	182	1,275	1,766	491
Saudi Arabia				1,400	1,772	372
Sub-Saharan Africa						
Cameroon	222	357	135	821	1,291	471
Cote d'Ivoire	1,310	1,601	291	2,567	3,736	1,170
ECOWAS-7						
Ghana	523	695	172	1,333	2,010	676
Guinea	1,570	2,312	742	2,125	2,930	805
Kenya	73	95	21	697	1,378	682
Liberia	163	260	97	513	611	97
Madagascar	2,417	3,262	845	2,904	3,959	1,054
Malawi	83	99	16	98	148	50
Mali	1,966	2,478	512	2,217	3,534	1,317
Mozambique	273	379	106	880	1,524	644
Nigeria	4,683	5,830	1,148	6,800	9,018	2,218
Rwanda	58	65	7	98	210	112
Senegal	764	899	134	1,858	2,621	763

Continued

Table A1. Country-wise changes in rice production and consumption around the world, *continued*.

Country	Production			Consumption		
	2017–2019	2028–2030	Change	2017–2019	2028–2030	Change
	----------1,000 metric tons----------					
Sub-Saharan Africa, *cont*.						
Sierra Leone	864	1,333	469	1,224	1,619	395
South Africa				898	980	81
Tanzania	2,055	3,278	1,223	2,255	3,523	1,268
Uganda	168	230	62	221	380	159
Zambia	30	42	12	40	92	52
Latin America & Caribbean						
Argentina	819	1,038	219	515	597	82
Brazil	7,649	7,328	(321)	7,383	6,923	(460)
Chile	115	144	29	267	326	59
Colombia	1,735	1,910	175	1,860	2,140	280
Costa Rica	102	118	17	243	293	50
Cuba	270	306	37	719	817	98
Dominican Republic	625	608	(18)	613	696	83
Guatemala	22	26	4	131	173	42
Guyana	647	1,081	434	187	429	242
Haiti	72	91	19	572	669	97
Honduras	63	88	25	205	252	47
Mexico	181	205	24	925	1,111	186
Nicaragua	280	343	64	377	420	43
Panama	219	236	17	320	344	24
Paraguay	718	933	216	60	79	19
Peru	2,251	2,499	247	2,477	3,025	548
Uruguay	853	1,010	157	45	50	5
Venezuela	195	198	3	647	825	178
North America						
Canada				393	452	60
United States	6,214	7,142	928	4,483	5,065	582
Europe & Central Asia						
Turkey	580	657	77	798	807	9
European Union-28	1,993	2,179	186	3,850	4,051	201
The rest of the world	8,670	8,860	190	15,181	15,193	12
World	496,051	523,404	27,353	486,653	525,516	38,863

Table A2. Country-wise changes in rice trade.

Country	2017–2019	2028–2030	Change	Country	2017–2019	2028–2030	Change
	----------	----------	----------	1,000 metric tons	----------	----------	----------
Exporters							
India	11,649	13,452	1,803	EU 28	320	416	95
Thailand	8,039	10,937	2,897	Australia	128	260	133
Vietnam	6,424	7,703	1,279	Peru	95	100	5
Pakistan	4,101	4,226	125	Guinea	93	100	7
USA	2,908	3,352	444	Cote d'Ivoire	77	50	-27
Myanmar	2,583	3,327	743	Egypt	30	100	70
China	2,245	2,667	422	Japan	65	70	5
Cambodia	1,333	2,036	703	Turkey	220	200	-20
Brazil	1,077	1,046	-30	Tanzania	33	30	-3
Uruguay	820	957	137	Venezuela	7	0	-7
Paraguay	714	864	150	Senegal	10	10	0
Guyana	455	646	191	Sri Lanka	6	5	-1
Argentina	368	445	77	Laos	-101	336	436
				Rest of world	977	521	-457
Total Exports					**44,677**	**53,855**	**9,179**
Importers							
China	3,767	4,031	264	Canada	405	452	47
Nigeria	1,733	3,197	1,464	Sierra Leone	360	287	-73
Ecowas 7*	2,155	3,411	1,256	Egypt	399	250	-149
Philippines	2,450	3,280	830	Liberia	343	351	8
EU 28	2,199	2,437	237	Sri Lanka	178	169	-10
Cote d'Ivoire	1,257	2,201	945	Hong Kong	324	396	72
Saudi Arabia	1,405	1,774	369	Peru	314	605	291
Iran	1,233	1,921	688	Singapore	319	320	1
Bangladesh	1,207	-290	-1,497	Turkey	486	349	-137
Iraq	1,178	1,416	239	Tanzania	233	276	43
Senegal	1,117	1,729	612	Thailand	250	250	0
South Africa	1,015	1,096	81	Mali	277	1058	782
Indonesia	1,167	1,232	66	Australia	231	173	-58
Malaysia	983	863	-120	Chile	162	184	21
USA	993	1,301	308	Costa Rica	141	176	35
Mexico	787	921	135	Colombia	186	307	121
Ghana	847	1,318	471	Honduras	131	173	41
Guinea	673	721	48	Uganda	63	160	97
Japan	667	682	15	Taiwan	106	126	20
Brazil	720	612	-108	Guatemala	110	147	38
Kenya	604	1,294	690	Nicaragua	93	83	-10
Mozambique	607	1,146	539	Panama	117	109	-8
Cameroon	598	935	336	Brunei	35	58	23
Cuba	450	511	61	Rwanda	40	145	105
Haiti	501	579	78	Dominican Republic	26	99	73
Vietnam	467	400	-67	Malawi	15	49	34
Venezuela	480	628	148	Zambia	10	50	40
South Korea	381	409	28	Pakistan	0	0	0
Madagascar	487	698	210	Paraguay	2	2	0
				Rest of world	7,194	6,601	-593
Total Imports					**44,677**	**53,855**	**9,179**

Notes: Authors' computation, based on the 2021 January baseline analysis of the Arkansas Global Rice Model.

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